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AUTOMOBILE TORPEDOES.

THE HOWELL TORPEDO, PRESENT AND FUTURE EFFICIENCY OF AUTOMOBILES IN GENERAL, AND PROBABLE TYPE OF FUTURE TORPEDO CRUISER AND DESTROYER.

Three Lectures delivered to the Officers in attendance at the Naval War College, Newport, R. I., October 26, 27 and 28, 1892.

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In presenting the Howell torpedo it will not be amiss to enumerate the essential features which the automobile should possess.

These are:—1. Maximum speed within an effective range of not less than 400 yards.

2.—Efficiency to maintain a set depth and rectilinear direction in the horizontal plane.

3.—A maximum rending force. The whole to be embodied in a shell having a maximum strength with minimum weight of material. Upon this base and as the result of practice, the present general outline of shell for automobiles has been developed. It will be necessary

in the general description of nomenclature to give an outline of the principal factory tests in the several stages of assembling, in order that the various functions of its mechanism may be more fully understood.

DIMENSIONS.

Model of 1892.

Length from nose tip to nose ring	6.52″
" " " ring to head locking ring	32.05″
" of cylindrical section	31.1″
" " after and tail sections	45.0″
" " tail cone	5.7″
" " " frame	1.75″
" " after face of tail frame to after edge of horizontal rudder	7.63″
Extreme length	129.75″
Diameter	14.2″

The shell is made from a hard rolled metal, the composition of which shows 80.39 per cent. copper, 19.68 per cent. zinc, and 0.1 per cent. lead. It is one-sixteenth of an inch in thickness.

WEIGHTS.

Practice head complete	130.25	pounds.
Cylinder	236.25	"
After and tail sections	125.75	"
Buoyancy	8.87	"
Total displacement	501.12	"

Hence coefficient of fineness of head	0.723
" " " " " after body	0.535
" " " " " whole torpedo	0.700

Total weight of war head	143.12	pounds.
" " " wet and dry gun-cotton	95.92	"

This gives a charge of gun-cotton equal to 19.1 per cent. of the total weight of the loaded torpedo. Specifications call for 17½ per cent.

AREA OF FINS AND RUDDERS.

Horizontal fins	42.5	square	inches.
Vertical fins	42.8	"	"
" rudders (each 10 sq. in.)	20.0	"	"
Horizontal rudder	27.0	"	"

GENERAL DESCRIPTION.

Curve of profile of the Howell.—A spindle of revolution represents the general profile, in which the head approaches a spheroid, the after and tail sections being a perfect spindle, the middle section a cylinder. The profile of the head is a curve of three radii, respectively 260.2," 41." and 11.8", beginning at the forward end of the cylindrical section, or head locking rings.

The radius of curvature of the after and tail sections is 227.57".

The shell is divided into four sections, namely, the head, middle or cylindrical, the after, and tail sections.

For convenience in mounting and dismounting, the detachable sections are the head, cylindrical, and the after and tail sections in one.

The head is dismounted by taking out the set screw in the bayonet-joint, then unlocking it. The after body, by removing the inclined screws in the locking rings. The shafts automatically detach in this section.

The Nose and False Point.—The former carries the firing pin and its mechanism, the latter the firing pin with its safety nut and additional weight equal to that of the firing pin mechanism. The nose with firing pin complete is used in connection with the war head; the false point with the practice head. The nose screws into a nose ring against a rubber gasket on the front end of the head.

The Head (1, Fig. 1).*—The war head contains the gun-cotton and detonator. The exercise head contains an equivalent in weight to that of the gun-cotton charge, consisting of a tank filled with fresh water; a filling hole closed with a screw cap is located in the after bulkhead. The tank is held in place by a cross brace which is screwed to the centering ring. The connection between the head and cylindrical section is made by a bayonet-joint lock secured in place by a set screw.

The Cylindrical Section (2, Fig. 1).—Contains the pockets for depth register, phosphide of calcium, also the fly-wheel, miter gears and driving shafts in which the motive power is generated for driving the propellers, working the impulse movement and pitch mechanism.

The connection with the after section is made by flange-joint rings locked with inclined screws. This locking ring carries a rubber gasket in a groove which effectually closes the joint.

* The figures referred to in the text will be found at the end of the article.

The After Section (3, Fig. 1).—Contains the immersion regulator, the impulse movement, its immobilizer and line sections of shafts. It is connected to the tail section by flange-joint rings locked with a set screw, then brazed solid around the joint.

The Tail Section (4, Fig 1).—Contains the stuffing-boxes for thrust bearings of propellers, their shafts and sleeves, also the tiller rod bulkhead. The rear end of this section is brazed to a tail ring, into which is screwed the tail cone. The latter contains the pitch mechanism and carries the tail frame, fins, rudders and propellers.

THE NOSE (Fig. 2).

As this portion of the torpedo contains the firing pin and its mechanism, which performs the most important work in the final act of the torpedo's run at the instant of contact with the object which it is necessary to destroy, it is therefore most essential that it should be compact and absolutely perfect.

It should be a safeguard against premature discharge in handling, and render it impossible to explode the charge before entering the water. It should be quickly attached at the last moment, previous to inserting the torpedo in the tube. It must be safe in manipulation and readily show without close inspection when in the active and inactive state. It must be effective whether striking the object perpendicularly to its surface or at an angle of 18° with the plane of contact.

The nose consists of a hollow bronze casting (183) which is connected to the head by a single screw joint with rubber gasket (198), and requires but a few seconds to attach or detach it. A steel pin (188) travels in guides (191) in the front end of the nose casting. A thread (185) is turned on the outer end of this pin, on which travels a safety nut (187) with propeller blades. The tip of the pin is capped with a pointer (186), which likewise acts as a guard to the propeller after it has traveled the length of its thread.

A spiral spring (189) on the firing pin seats on the safety cap (184) which is screwed in the outer end of the nose. The inner end of the spiral works on a flange turned on the nipple end of the firing pin. A sear (194) is attached to the cap which acts as in cocking when the pin is set for firing. When prepared for action the safety nut is screwed against the cap, and a soft metal stop pin (190) inserted in the firing pin through the hole in the cap. In this position the spiral spring on the firing pin is compressed and has sufficient force to explode the detonator.

The pin is now inoperative. Upon impact with the water, the safety nut travels out on the pin to the guard and there continues to revolve freely. The pin is now operative. Upon contact with an object, the stop pin is sheared, and the force of the blow, together with the spiral spring, insures its action. The length of firing pin projecting beyond the nose shows whether it is cocked or not.

It is to be remarked, however, that this firing pin does not automatically lock itself at the end of the run of torpedo.

Small holes inclining strongly backward in the nose (183) admit water at the end of the run into the hollow nose chamber, which dissolves the wafers (195*a*) in the primer case cover (65) and drowns the dry gun-cotton and detonator (196), thus rendering a loaded torpedo innocuous.

THE HEAD.

Each torpedo has two heads, viz. the Practice and War Heads.

The practice head (Fig. 1, elevation) is attached to the torpedo when stored in racks.

In the practice head a central tube (7) passes through the water tank (6) and carries lead balance weights which are notched and slide on a feather in giving longitudinal trim to the torpedo. The false point (5) screwed down against the forward bulkhead on a gasket forms a water-tight joint.

The war head (Fig. 1, plan) carries a thin brass cylinder having a diameter equal to that of its centering ring, and is soldered into the shell head and supported by said ring. After the wet gun-cotton is placed, the charge head is soldered into the rear end of the brass cylinder. The charge head has a water hole and cap for correcting the density of the gun-cotton, and is supported by a charge brace.

The primer pocket (64, Fig. 2) contains the dry gun-cotton. It is closed at its after end, and has a flange at its forward end soldered to the nose ring (63). It holds the primer case which carries the percussion detonator (196) at its forward end.

CYLINDRICAL OR MAIN SECTION.

The depth register is held in place by a ring screwed into a socket against a flange, and a rubber gasket on the right side of the cylinder in the plane of the axis of fly-wheel. The depth register is supported by a light bracket soldered in the cylinder. The phosphide of calcium pocket is water-tight and located on top of the cylinder forward of the fly-wheel. In practice a can of phosphide of calcium is inserted

for sighting the torpedo after its run. In war service this pocket is closed by a cork plug, and a water-tight cap is screwed into the depth register socket. This section is stiffened by a strengthening ring. The guide trunnions are mounted on this section with their after ends near the center of gravity of torpedo and above the horizontal plane of the axis of the fly-wheel. In the wheel frame (Fig. 1, *a*) are mounted the fly-wheel (209), its gears (212) with their shafts and couplings, the roller bearings (216) for axis of fly-wheel, and ball bearings (217) for end thrust. The fly-wheel shaft (211) carries a clutch (218) on the starboard end which locks with a double intermediate clutch (219) in a stuffing-box (223); the outer end of this clutch (221) connects with the motor clutch on the launching tube when spinning up the fly-wheel. Oil holes, closed by oil plugs, lead to oil pipes for the different bearings. Immediately abaft the wheel is a light brass screen attached to the wheel frame to prevent the throwing of oil and water by the former on the regulator.

The locking joint between the after end of the cylindrical section and the forward end of the after section is effectually closed by a rubber ring in a groove drawn against the ring faces of the joint by the inclined screws.

AFTER SECTION (3, Fig. 1).

This section carries the support ring, in which is mounted the immersion regulator, which consists of a pressure piston and its spring, the horizontal and vertical pendulums, the immobilizer and impulse mechanism, and the connections to the propeller shafts and tail. Two hand holes (43*a*) are located on top of this section which are closed by covers screwed down on rubber gaskets into sockets, and give access to the immersion regulator for adjustments, inspection, and oiling. On the port, or left, side of the torpedo (see plan view), in the support ring, is cast a flange socket which carries the pressure piston (43*b*). On the starboard, or right, side, opposite the pressure piston, access is had to the regulating screw of the pressure piston spring by removing the cap (43*c*).

The tail section is united to this section by joint rings (45), as described, and carries the tiller-rod supports and propeller shaft hangers (50). The tiller rods (48) and immobilizing rod (49) pass through small stuffing-boxes (47) in the tail bulkhead (46).

The immobilizing rod has a longitudinal motion given by the pitch frame to which its after end is connected. This motion is pro-

portionate to the revolutions of the propeller shafts after launching, and produces a certain effect upon the H. R. (horizontal rudder) pendulum which actuates the H. R. pallet and, through the impulse mechanism, the horizontal rudder. It holds the pendulum forward a short interval of time (from 0.5 second to 3½ seconds after launching, depending upon the tendency of the torpedo to dive), and by means of the cam buffer (49*a*), the lever (49*b*), and the link (49*c*), produces an up-rudder effect. The propeller shaft sleeves (51), secured to the tail bulkhead and soldered to the shell, are prolongations of the stuffing-boxes (52) which are easily reached from the outside of shell. From the tail bulkhead forward to the head locking rings is one compartment.

THE TAIL.

The tail cone (53) is a hollow truncated cone frame, to which are secured casing plates shaped to the cone. These form openings for reaching the pitch mechanism gear, the immobilizing rod, and V. R. (vertical rudder) tiller adjustments, also the bulkhead stuffing-boxes. The cone is secured to the tail bulkhead and is not water-tight.

The tail frame (55) is secured to the tail cone by a tail bolt and supports the horizontal fins (59) and horizontal rudder (60), the vertical fins (56) and vertical rudders (57).

The horizontal rudder frame (58) is screwed to the tail bolt and its ends are connected with the horizontal fins by vertical shoes.

The tail frame also forms bearings for the propeller shafts and carries phosphor-bronze collars between their stuffing-boxes (52) and the frame to define the shafts' longitudinal position. The thrust is taken from the forward collars by the stuffing-boxes.

The casing plates which enclose the propeller shafts are dismountable, likewise the intercostal fins between the tail frame and stuffing-boxes, also the cylindrical covers forward of the propellers (61). These form flush surfaces which act as water guides to the propellers.

To the tail frame are screwed the propeller tips (62); these act as a steady bearing for the ends of the shafts.

A rudder stop (62*a*) limits the upthrow of the rudder on impact with the water in launching and prevents any shock being conveyed to the H. R. pallet.

IMMERSION REGULATOR (Figs. 3, 4, 5).

The support ring (Fig. 3, 89), in which is mounted the regular piston chamber as already described, supports the H. R. pendulum frame (106) on a knife-edge pivot (113) in a bracket at the top of the ring; also the immersion spring (95), the impulse movement (119, 120, 128 and 130), and the V. R. pendulum (117), located on the port side of the torpedo, swinging on its pivot (115).

The principal feature in the immersion regulator is the angle guide (131*a*, Fig. 4) which transmits to the impulse movement (124, Fig. 5) the direction and angular throw to be given to the horizontal (diving) rudder (60, Fig. 1) through the H. R. tiller rod (127, Fig. 5). The angle guide (131*a*, Fig. 4) forms a part of the collar which controls its angular motion in its bearings (149*a*), when actuated by the H. R. pendulum or pressure piston (138*a*). The angle guide has two light flat guide springs parallel to each other and separated about 0.08 of an inch by a projecting pin on its side. The pallet (128, Fig. 5) is mounted on its pivot in the extension (127) of the H. R. tiller rod. These guide springs are separated by the width of the lug face on the end of the angle guide (131*a*, Fig. 4) and admit of divergence from the riveted ends on the angle guide, as they easily bend outward.

The piston rod (146*a*) carries a guide lug (151*a*) which works in the cam slot in the collar of the angle guide; hence when the piston rod moves out or in by the action of pressure on the piston face (139*a*), the collar will turn, also the angle guide, as its support bearings prevent it from taking up a longitudinal motion with the rod.

The piston rod is free to turn in the inner piston face and on its adjustable bearings (145*a*). The angle guide is connected with the H. R. pendulum by the adjustable lever (149*a*) and a pin.

When the H. R. pendulum oscillates, the angle guide lever turns the angle guide and cam collar, and with it the piston rod, owing to the guide lug in the cam slot. Therefore the piston and rod move in and out under varying pressure, turning the angle guide, the cam collar, and, by means of the guide lug in the cam slot, the piston rod. The piston is free to rotate the angle guide, and the H. R. pendulum to rotate both angle guide and piston rod without material resistance from the pendulum and piston working one against the other. The pendulum dominates the piston in the angular throw of the angle guide, which controls the H. R. pallet, and alone causes it to engage five teeth of the impulse rack. The piston alone engages three teeth.

The relative angular effect is adjusted by the travel of piston, angle of cam slot, and throw of the pendulum in arc, and the leverage of pendulum to angle guide. Hence whatever angle is given to the angle guide by the combined action of pendulum and piston, acting conjointly or independently, the H. R. pallet (128, Fig. 5) takes the same angle when the tiller rod in which it is mounted returns to its normal position by the action of the H. R. return springs (133) after an impulse produced by the reciprocating racks (124) on the pallet (128) (also as in Fig. 9). The flat springs (*s*, Fig. 8) of the angle guide acting on the pin *p* of the pallet, guide it to its new angular position to engage the teeth of the impulse racks (124, Fig. 5).

The angle guide springs are so light that the angle guide is always free to take whatever new position the combined action of piston and pendulum may produce upon it, while the pallet and its tiller rod are being pushed forward or aft by the impulse racks. The pallet pin (*p*, Fig. 8) always slides between the springs *s*, the one in contact with the pallet pin *p* yielding easily when the angle changes; and, when the pallet is free to return to normal (parallel to its tiller rod), this spring throws the pin *p* instantly against the opposite spring without subsequent vibration, thus leaving the pallet to engage the impulse racks for such effect on the rudder as the angle guide may define.

THE IMPULSE MOVEMENT (Figs. 3 and 5).

This consists of a frame (122) bolted to the support ring (89). The two impulse racks (124) slide in the frame with reciprocal movement, alternately approaching each other and receding by the action of the cam (120), operated by the worm and gear 119.* A stud on the arm (125) of the after rack, and a stud (126) on the forward rack work in the elliptical groove in the cam, one-half of a revolution of which gives one complete impulse to the racks outward and inward. Thus one complete revolution of the cam gives two complete reciprocating impulses of the racks, causing them to approach each other at the lesser diameter of the groove and separate at the greater diameter.

This reciprocating motion of the racks obviates the loss of an impulse; for one end of the pallet (*p*, Fig. 9), being engaged by the rack *A* and carried forward, acts on the tiller rod, thus drawing the

*In the new impulse a worm and gear on each shaft, immediately abaft the impulse frame, are connected by a transverse eccentric shaft on which two eccentrics connected by rods to the racks give reciprocal impulse.

tiller t forward to t^1 and giving up-rudder action R^1. In the meantime the angle guide changes its angular position sufficiently to tip the pallet when free of the impulse rack A into the position p^2 so as to engage six teeth of the rack F at the next impulse, and, carried aft, acts on the tiller again, thus pushing the tiller t aft to t^2 and giving down-rudder action R^2.

The H. R. tiller rod (127, Fig. 5) and V. R. tiller rod (129) with their pallets and the racks (124) are held in the frame by the caps (123). The tiller rods are always brought back to exact normal position after each impulse by the return springs (133 and 134), aided by the intensity of water pressure on the rudder surface.

In the model of 1892 the return springs are flat and vertical and fastened to the forward end of impulse frame.

When the racks are in the normal outward position, as in Fig. 5, the torpedo level, and the pressure piston normal (midway of travel), the H. R. pallet (128) is underneath and in the opening in the tiller rod extension frame parallel to the latter, and just clearing the racks.

If the torpedo is diving or rising below or above its set depth so as to affect the H. R. pendulum and piston, separately or conjointly, the action of the angle guide will be such as to cause one end of the pallet to engage one or more teeth of the impulse racks as they draw together, depending on the angle of dive or rise, as the case may be. The effect, or angular throw of rudder, is therefore graded according to the number of teeth engaged by the pallet in the racks regulated by the demand made upon the angle guide by the H. R. pendulum and piston.

The number of impulses are 4.5 per second at 8000 revolutions of shafts. The operation of the immersion regulator for controlling the torpedo at a given set depth is as follows: the immersion spring (95, Fig. 3) is set up by means of the regulating screw (102) for a tension equal to the pressure exerted on the effective piston area (90) (mounted in its chamber) by the column of water corresponding to said depth, and through the lever (97) working on its knife-edge pivot (96) holds the piston at its outward position until the hydrostatic pressure equals the spring tension; thus the piston in equilibrium is normal and midway of travel. If then the H. R. pendulum is at its vertical normal position (torpedo axis horizontal), the angle guide is adjusted to hold the H. R. pallet horizontal, the horizontal rudder likewise stands at level, and the torpedo runs at set depth.

The torpedo being *above set depth*, the pressure on the piston being less than the spring tension, the piston will be out as at p^3 (Fig. 10), and the piston rod stud s will be at the point s^3 in the slot in cam collar G; this will tip the angle guide so as to make the pallet p engage the impulse rack with the forward end of the pallet as at p^3, and produce a certain amount of down-rudder, causing the torpedo to dive (R^3, Fig. 9). The pendulum then swings forward and the effect is such that, at a given angle of the pendulum to the torpedo axis, the angle guide is turned by the pendulum, the former tipping the after end of the pallet up in the position p^1 (Fig. 9) so as to engage the after impulse rack A and produce a certain amount of up-rudder in the direction R^1, thereby checking the torpedo's dive and limiting said dive to any desired angle for which the angle guide may be adjusted.

Therefore the turning effect of the pendulum on the angle guide is greater than that of the piston rod's longitudinal movement through its guide stud s acting in the cam slot of the collar G of the angle guide (Fig. 10).

When *below set depth* and approaching it, the reverse action takes place, the same principle controlling the angle of rise. These angles are with reference to the torpedo axis as a horizontal. The pendulum buffer springs (108, Fig. 5) act to delay the swing of the pendulum more or less and adjust said angles at will, the effect of pendulum angles to torpedo axis, however, remaining constant.

The pendulum action on the angle guide through the lever *ol* (Fig. 7) is complete when the pendulum touches either fixed buffer m' or m'' (or as in Fig. 5), and the stronger the spring (108) the more it resists the swing of the pendulum, therefore the more the torpedo axis must tip before the pendulum is opposed by rigid resistance at the buffer.

When the torpedo is below set depth and diving (or point down), the combined turning effect of pendulum and piston is exerted upon the angle guide to tip the after end of pallet p (Fig. 9) to position p^1 to engage the rack A for full up-rudder effect R^1. The total turning effect (8 teeth, pendulum = 5 teeth + piston = 3 teeth) is not relatively transmitted to the pallet by the angle guide, as the impulse racks only have a depth for six teeth. Hence the light angle guide springs s (Fig. 8), acting on the pallet pin p, are yielding and thus absorb the extra angular motion of the angle guide, which is equal to three teeth. With the torpedo above set depth and point up, a similar

result occurs and like absorption of a portion of angle guide effect. The H. R. tension springs *s* (Fig. 9), mounted in a sleeve forming a part of the tiller rod near the rudder, are adjusted to regulate the amount of force transmitted from the impulse racks to the horizontal rudder at the different angles of its throw, and absorb the shock of an otherwise rigid impulse action.

VERTICAL RUDDER ACTION.

In order to steer the torpedo on an even keel and insure its rectilinear direction in a horizontal plane, the support ring (89, Fig. 3) carries a transverse swinging pendulum called the V. R. pendulum (117) which actuates an adjustable V. R. angle guide (132) to control the angle of the V. R. pallet (130, Figs. 3 and 5) in reference to the upper impulse racks. When the torpedo rolls by virtue of an exterior force acting upon the gyroscopic force of the fly-wheel, as in launching from a broadside under way or from other causes, the V. R. pendulum (117) swings, under control of its buffer springs, thereby turns its angle guide (132), tips its pallet (13c) to engage its impulse racks and transmits to its vertical rudders (57, Fig. 1) a throw proportional to the angle of roll, and in the direction to produce impulses of the vertical rudders acting oppositely to the original on the gyroscopic force, so as to *roll the torpedo back* to an even keel; then the angle guide holds the pallet parallel to and clear of its impulse rack.

The V. R. pendulum pivots on two adjustable central points in the axis of its fulcrum, and is controlled by buffers and springs. Two light angle guide springs also control the V. R. pallet action, by an adjustable angle guide lever to V. R. pendulum frame.

HORIZONTAL RUDDER PENDULUM (Fig. 5).

The frame (106) holds the bob (107) by suspension springs (110). The weight of the pendulum is 9.5 pounds. Its swing is limited by fixed buffers (109) and regulated by the spring buffers (108). The bob is guided and steadied by guide rollers (114, Fig. 3). The suspension springs absorb all shocks of the pendulum upon its knife-edge support.

PRESSURE PISTON (Fig. 4).

The travel of the piston is limited by check nuts (137*a*), on the outer end of rod. The piston proper (138*a*) is cup-shaped. The

flange ring (136*a*) seats on a rubber ring (142*a*) in a groove in the pocket flange of the support ring.

The rubber diaphragm (139*a*) is secured to the piston by a metal washer and set nut (143*a*); its outer rim is secured on the flange ring by a washer and set ring (135*a*), which makes a water-tight joint. The adjustments of piston rod (146*a*) are made by the lock nut (144*a*), the adjusting nuts (145*a*), and socket screw (138*a*).

EFFECTIVE IMPULSE ACTION.

The angular value of the pallet for one tooth of the impulse rack = 2° 17′ 30″. Full stroke of piston, three teeth, = 6° 52′ 30″. Half swing of pendulum, five teeth, = 11° 27′ 30″. This is the motion of the pendulum for 1° swing each way from normal. The longitudinal motion of the tiller rod for one tooth = 0.07″; for six teeth the longitudinal motion = 0.42″, as actuated by the impulse racks. The motion of the racks is 0.5″, thus allowing .08″ clearance for the pallet to take up its new position. The rudder is usually connected by the tiller rod so that each tooth of the impulse rack gives 3° angular throw of rudder. This can be varied by adjustment to 4° or 2° 30″.

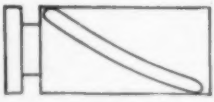
The tension of the tiller rod springs can be varied to suit the tendency of individual torpedoes to run above and below set depth.

PITCH MECHANISM (Fig. 6).

The pitch mechanism is intended to automatically equalize the speed of the torpedo while the speed of revolutions decreases. With a given number of revolutions of propellers the blades are set at a given pitch. The ratio of revolutions of fly-wheel to those of propellers is as 5 to 4.

If, while the speed of revolution of the propellers decreases, the blades are turned to a higher pitch proportionate to this decrease, the original speed of the torpedo may be approximately maintained.

The principal parts are the trigger (80) in a support (81), mounted on the port horizontal fin; the trigger (80) is held forward by the spring (82) on its shank, an arm of which carries a stud which works in a socket in the worm (78) and prevents the latter from turning with the propeller shafts when spinning up. The inner end of the trigger shank is eccentric and works in a square-faced collar in a groove in the worm clutch (79), which slides on a feather on the propeller shaft, turning with the latter and having a longitudinal motion.

The worm (78), in action, operates the worm gear (76), the pinion (77), the intermediate gear (74), its pinion (75), the cam gear (72) on which is mounted the revolving cam (72*a*), the pitch frame (83) with a stud working in the cam groove (72*a*) giving a longitudinal motion by means of the pitch forks (83*a*) to the sliding cams (85), by working in annular grooves on the forward end of these cams, which slide on feathers on the propeller shafts and have three flat sides, thus each with a cam groove, thus  in which travels a stud attached to the blade lever (86) of the blade (87). Each blade is threaded at its base and screws into the propeller hub and is free to turn about its axis according as the blade lever is moved by the sliding cam groove. When the torpedo is prepared for a run, the cam gear is set at such a point of its revolution that the stud in the pitch frame, working in its groove, has drawn the frame and sliding cams forward, thereby turning the propeller blades to the required initial pitch marked on the rim of the cam gear, and referred to the index finger (88). As the torpedo enters the water, the trigger is thrown back by impact, and catches under a small spring on the trigger support. The eccentric shank causes the worm clutch to move forward, engaging the worm and making it revolve with the shaft. The gears then take up their motion and the pitch frame moves slowly aft, pushing the revolving sliding cams towards the propellers, thereby turning the blades by the action of the blade levers to a higher pitch as the speed of revolutions of the shafts decreases.

The ratio of gearing to shaft is intended to be such that the cam gear will make one revolution while the torpedo is traveling its service range of 400 yards in the present type.

In the model of 1892 the cam curve slotted in the upper face of the revolving cam throws in towards its center. Its construction is such as to give an easy curve for the travel of the pitch frame stud when the cam gear is at its greatest speed, as at the beginning of the run.

The effort of the developed blade areas so nearly coincides with their revolving planes that the work on the sliding cams is very small.

The blades are formed to nearly the maximum pitch for which they are to be used, as a variable pitch blade.

To adjust the cam gear before launching, the screw pivot (77) and worm gear are removed, and the cam gear (72) turned to the desired pitch; the gear and pivot are replaced and the trigger (80) set forward to engage the worm.

In order to overcome the effect of inertia in the H. R. pendulum in launching, and eliminate this error from the proper functioning of the immersion regulator, a cam buffer or immobilizer (49*a*, Fig. 1), operated by the immobilizing rod (49) attached to the pitch frame, holds the pendulum forward against its buffer for an interval of time controlled by the revolving cam, giving longitudinal movement aft to the pitch frame. The latter not only performs this function, but also regulates with absolute certainty the amount of increase and ratio of variable pitch of the blades to the decrease in the number of revolutions per minute, and thereby outlines a limit of blade area whose frictional surface does not necessarily absorb the developed energy of the fly-wheel without a proportional increase in the speed of the torpedo.

With the blades set at an initial pitch of 5.5 inches and the revolutions of propellers 8000, the average slip is found to be about 23 per cent. The diameter of propellers is 6 inches; the helicoidal area of each blade is 3.16 square inches, and the number of blades in each propeller three.

DETAILS OF FACTORY TRIALS AND FINAL ASSEMBLING.

The first trial consists in spinning up the fly-wheel, assembled in the wheel frame with bevels attached for the driving shafts, to a maximum speed of 10,000 revolutions per minute. The wheel is then maintained at this speed for 10 minutes consecutively, when it is allowed to run down, the average time of running down being 69 minutes. Great care is exercised in practically reducing the friction in roller bearing boxes on the fly-wheel shaft, and end thrust ball bearing cases, so as not to diminish the time of running down to less than 65 minutes. The weight of the fly-wheel is 131.5 pounds. It is carefully balanced on its driving shaft previous to assembling, and all eccentricity removed. This test of its physical characteristics necessitates a very high elastic limit and a wide margin between it and the

ultimate strength in order to guard against any liability of deformation. The minimum elastic limit of the steel used in the fly-wheels is 48,000 pounds per square inch. The specific gravity of the steel is 7.85. At a speed of rotation of 12,000 revolutions per minute, the fly-wheel will have reached the minimum elastic limit.

The fly-wheel in its frame is now assembled in the cylindrical section, to which it is firmly attached by screws, and by brazing the flange faces of the fly-wheel frame to the inner face of the shell. The double intermediate clutch in its stuffing-box forms the connection through the shell between the motor and the shaft clutch. It has longitudinal play in its stuffing-box, and the shaft clutch throws it off when the motor clutch is detached, thereby reducing the friction on the fly-wheel.

The trunnion guides are mounted on the outside of the shell and are six inches in length with after ends in the transverse plane of the center of gravity of the torpedo, and 1.5 inches above the horizontal plane. They are riveted through to inner plates and soldered to the shell and form the radial bearings which take the weight of the torpedo when loaded in the launching tube. The strengthening and locking rings having been adjusted, this section is placed in the trial launching tube and a second test made at 10,000 revolutions, in order to insure final success when the torpedo is wholly assembled. Oil holes, closed by screw plugs on rubber gaskets, lead to oil pipes connected with the different bearings in the fly-wheel frame.

The immersion regulator, impulse mechanism, and speed regulator then follow. The immersion regulator and impulse mechanism, mounted in its support ring, is placed in a skeleton frame in the position occupied in the shell. The tail section, wholly assembled and attached to the tail cone, the latter carrying the speed regulator or pitch mechanism, with tail frame, fins and rudders, is also placed in the skeleton frame in the relative position occupied in the torpedo. The fly-wheel is mounted in this frame in its position. The frame is free to revolve in the vertical plane about the axis of the fly-wheel. The shafts for driving the propellers are then connected and lined up and propeller hubs placed. The motor in position, adjusted to the fly-wheel, stands on its own base. It is thrown into or out of action with the fly-wheel by the clutch already described. In the immersion tests the pressure piston is connected with a column of water, which is carried in a 3-inch pipe by means of a hose and cup screwed over the face of the piston. This pressure can be varied at will for any

depth to a height representing 25 feet of salt water. In the immersion regulator tests the pressure is usually set at 10 feet. The skeleton frame is carefully leveled, which represents the longitudinal axis of the torpedo *in the horizontal plane.*

The fly-wheel, impulse mechanism, shafts, and speed regulator are now run at a moderate speed of 4000 or 5000 revolutions until all parts become smoothly adjusted in their bearings without undue friction.

The fly-wheel is then spun up to 10,000 revolutions for a period of ten minutes.

The speed is then reduced to 6000 revolutions and the pressure piston spring set up until its tension equalizes the water pressure; this represents the torpedo at set depth, consequently pressure piston midway of travel.

The H. R. pallet is now free of the impulse racks and diving rudder horizontal.

The next step is to practically determine the *free dive* and *free rise* angles. These indicate the angles at which the torpedo may dive and rise without action of the H. R., the latter remaining normal in the plane of the longitudinal axis of the torpedo.

For example, we will assume the free rise angle to be 1° 15′, and free dive angle to be 1° 00′.

The column of water is then increased to 12 feet, which represents the torpedo *below* set depth and *piston in.* Under these conditions, the torpedo being *level,* the action of the pressure piston is such as to tip the angle guide and cause the rear end of the H. R. pallet to engage three teeth of the impulse racks which push it forward, thereby giving 9° of *up-rudder* (Figs. 10 and 9).

It must be remembered that the skeleton or test frame represents the *after body* of the torpedo, or that portion included between the fly-wheel and H. R.

Hence, if the test frame is lowered, it represents the torpedo *as rising,* or *point up*; if raised, *as diving,* or *point down* (Fig. 10*a*). The test frame is now lowered, which brings the axis of the torpedo point up 1° 15′, the H. R. pendulum swings aft, and the rear buffer spring is set up until the pendulum tips the angle guide so as to bring the H. R. pallet to its normal position, *i. e.,* horizontal to the axis of torpedo and clear of impulse rack; hence no rudder angle.

Consequently the pendulum action neutralizes the piston action, and this constitutes the *free rise angle sought* with the *rising buffer spring* practically adjusted.

The column of water is now decreased to eight feet. Torpedo *above set depth* and *piston out.* The test frame is again leveled and the action of the pressure piston tips the angle guide so as to cause the *forward end* of the H. R. pallet to engage three teeth of the impulse racks, which push it aft, thereby giving 9° of *down-rudder* (Figs. 10 and 9). The test frame is now raised until the axis of the torpedo is 1° *point down.* The H. R. pendulum swings forward and the forward buffer spring is set up until the pendulum tips the angle guide so as to bring the H. R. pallet to its normal position again, which gives no rudder angle. Hence again the pendulum action neutralizes the piston action, which is the *free dive angle sought* and the *diving buffer spring* also adjusted.

By weighing these springs their value in ounces is readily determined. This, however, is not done until the following data have been observed.

IMMERSION REGULATOR TESTS.

Torpedo No. 7. Date, October 15th, 1892.

Compression, tiller rod springs: diving = 32.50 pounds; rising, 32.50 pounds.

H. R. pendulum buffer springs: diving = $\frac{1}{4}$ ounce; rising = $1\frac{1}{2}$ ounces.

Position of Piston.	Angle of Torpedo.	Teeth Engaged.	Angle of H. R.	Remarks.
Midway of travel, or set depth.	1° 40′ D	5 A	15° U	
	1° 00′ D	3 A	9° U	
	30′ D	1 A	3° U	
	Level.	0	0	Travel of piston 0″.13.
	37′ U	1 F	3° D	Pressure salt water = 10 ft.
	1° 15′ U	3 F	9° D	Sensitive to change of pressure in 8″.
	2° 00′ U	5 F	15° D	
In, or below set depth.	2° 00′ U	2 F	6° D	1 tooth = 3° H. R.
	1° 15′ U	0	0	Forward pallet = Down H. R.
	37′ U	2 A	6° U	After " = Up "
	Level.	3 A	9° U	
	30′ D	4 A	12° U	
	1° 00′ D	6 A	18° U	
	1° 40′ D	6 A	18° U	
Out, or above set depth.	1° 40′ D	2 A	6° U	
	1° 00′ D	0	0	
	30′ D	2 F	6° D	
	Level.	3 F	9° D	
	37′ U	4 F	12° D	
	1° 15′ U	6 F	18° D	
	2° 00′ U	6 F	18° D	

H. R. pendulum forward engages after pallet.
H. R. pendulum aft engages forward pallet.
Speed at tests, 6000 revolutions.
Full dive angle, 1° 40′.
Full rise angle, 2° 00′.
Free angle of dive, 1° 00′.
Free angle of rise, 1° 15′.

The above tests having been found satisfactory, the skeleton frame is dismounted. The support ring is soldered in place in the after section of the shell, also the hand hole plate and locking rings. The after and tail sections are then connected and the joint finally brazed.

The torpedo now being wholly assembled and lined up, the longitudinal eccentricity of the axis is determined, and if greater than 0.02″ it is corrected by the inclined screws connecting the cylindrical and after sections. It is then passed through the gauge, 14.20″ in diameter.

The final spinning up in the launching tube is now made at 10,000 revolutions for a period of 10 minutes. This insures the practical working of the fly-wheel, shafts, propellers, impulse and pitch mechanisms.

TANK TESTS.

1. The balancing test is made in a tank of salt water 20 x 2½ x 3 feet deep. Straight edges placed across the tank with sliding perpendicular scales over the locking rings at each end of the cylindrical section indicate when the torpedo is floating horizontally. This condition is insured by moving the lead weights in the tube located in the fresh water tank in the head.

2. The center of buoyancy is determined by forcing the torpedo down with a horizontal straight edge, transversely placed on the cylindrical section, until wholly submerged.

3. The buoyancy is determined by adding small lead washers on a cord until the torpedo sinks horizontally. This cord encircles the shell in the transverse plane of its center of buoyancy. The cord and lead weights are removed and weighed in the water, which gives the buoyancy in pounds.

4. The center of gravity in air is then determined by balancing the torpedo on a knife edge.

5. The practice head is removed and its center of gravity determined in order to define the center of gravity of the loaded war

head. The head is again attached and the torpedo relined on a template.

6. The total displacement is determined by weighing the torpedo and adding surplus buoyancy.

The following table will show the results of tank tests:

Center of gravity of practice head forward of head locking ring	17.15″
Center of gravity of war head forward of head locking ring	17.10″
Center of gravity of torpedo, with practice head, abaft head locking ring	19.40″
Center of buoyancy wholly submerged abaft head locking ring	15.80″
Total weight with practice head	492.25 pounds.
Surplus buoyancy	8.87 "
Total displacement	501.12 "

The test for leakage is made on the trial grounds by sinking the torpedo to a depth of 15 feet for a period of five minutes. This is done with light safety lines attached at each end of torpedo and lead weights fastened around the shell.

This finishes the factory tests and brings the torpedo up to the point where it is ready for trial runs.

SERVICE ADJUSTMENTS.

The most essential feature in practice is a proper adjustment of the several functions of the immersion regulator.

It therefore becomes necessary for each torpedo officer to make himself familiar with the principle, in detail, upon which is based the individual action of the immersion regulator of each type of torpedo under his charge. This involves a practical study of the several adjustments and the methods in use to verify them. It also demands his personal verification of all practical adjustments in each torpedo, and the most careful analysis of any irregular action during practice runs and trials. Observe the vessel of the future in which the practice trials and runs of automobiles are rigidly executed in conformity to the Torpedo Manual which will be issued by the Bureau of Ordnance, and you will there find the successful torpedo officer. I unhesitatingly say successful, because of the fact that each and every

instruction laid down for his guidance is based upon practice under all conditions in which the automobile could be exercised. Furthermore, in order to execute these instructions he must be thoroughly acquainted with its practical requirements. Hence the individual labor that must be expended to attain that degree of proficiency which will insure the successful handling of the automobile in the near future.

INITIAL DIVE.

The initial dive and its duration from impact to return to set depth is dependent upon three conditions:—

1. Upon having H. R. tension springs of high initial and maximum tension. In practice the test results give initial, 32 pounds; maximum, 55 pounds. With an initial dive having a velocity of 50 feet per second, and with a H. R. area of 27 square inches, the rudder having a maximum throw of 18°, the intensity of pressure exerted on the rudder is $AKV^2 \sin^2 \theta$, in which:

A=area of rudder=27 square inches.

K=0.019782 pressure on 1 square inch of rudder surface.

V=29.5 knots.

θ=18° maximum rudder angle.

Then $27 \times 0.019782 \times \overline{29.56}^2 \times \sin^2 18° = 44.56$ pounds, which comes within the margin prescribed.

2. Upon immobilizing the action of the H. R. pendulum, *i. e.* setting it against the forward buffer as in *point down*, and making duration of contact with the immobilizer from 0.5 to 3.5 seconds, depending upon the action of the torpedo to dive after impact, as shown on the depth register card.

3. Upon maximum rudder angle, the area of the rudder remaining constant. Take the first case to illustrate. (See Fig. 10*b*.)

No. 1 curve is typical of the best possible form in the action of the immobilizer to control the torpedo. Set for 10 feet, the initial dive is less than 15 feet, or less than 1½ times the set depth. In four seconds of time, or at 68 yards, the torpedo has returned to set depth and within the limit of its full rise angle of 2°.

The maximum rudder angle is sufficient, also the initial and maximum tension of the H. R. tiller rod springs as shown in the curve of rise wherein the first vertical rise above set depth should be less than three feet under favorable circumstances, viz. a smooth sea.

The second vertical dive below set depth is less still, and the

second vertical rise likewise diminishing. The torpedo then runs its range with a less variation than 18 inches above or below the set depth.

No. 2 curve shows the action of the torpedo without immobilization of the H. R. The result is a sudden initial dive. It also represents the want of sufficient maximum rudder angle by the extreme depth reached, and length of time in returning to set depth.

No. 3 curve is the result of too much of an interval of immobilization, and weak H. R. tension springs, as the torpedo comes to the surface immediately after impact with but slight initial dive, and runs on the surface by virtue of its buoyancy, and the power of the H. R. being absorbed in the weak tension.

No. 4 curve represents too long an interval of action of immobilizer, and not sufficient maximum rudder angle.

LONGITUDINAL ECCENTRICITY.

Place the torpedo on a template and line up, using the two locking rings at each end of the cylindrical section for a base of reference, and the margin of nose ring and tail cone to determine respectively in the four quadrants the head and tail eccentricity. There will, however, never be any appreciable head eccentricity, as the locking rings of these two sections are squared up after final assembling in the shell. The lining up should be done with the greatest possible care, as any mistake in the determination of eccentricity in the horizontal plane becomes a constant angle of deviation in that plane.

VERIFICATION OF IMPULSES AND RUDDER ANGLES.

Level the torpedo carefully. This work may be done on board ship, in port, by placing the torpedo fore and aft in the vertical plane of the keel and leveling up. Take off hand hole plates and throw out the action of the immobilizer. Attach the H. R. angle gauge to rudder frame. Then revolve the fly-wheel with the hand crank clutch, at the same time elevate and depress the head, i. e., *point up* and *point down*, noting the angular throw of rudder for each angle of inclination of axis, as in the immersion tests; the impulse cam also, to make one revolution for each angle of inclination, commencing with its major axis parallel to that of the torpedo as the origin.

SPEED REGULATOR.

Note the position of the revolving pitch cam and observe that it is always set for the initial pitch, marked on its pitch circle, which will

give the speed at 10,000 revolutions of fly-wheel. In order to change the pitch, remove the first follower from the meshes of the worm on the shaft, then turn with the fingers the revolving pitch cam to higher or lower pitch required, then replace and screw down the first follower.

Also test the action of the pitch trigger and its collar, by throwing it into and out of action with the worm collar.

IMMOBILIZER.

Set the immobilizer for interval of contact with H. R. pendulum, as given in the record accompanying each torpedo, or as may have been found most advantageous in practice with the Howell. Replace hand hole plates.

LEAKAGE.

Lower the torpedo over the side into the water. Receive it alongside one of the ship's boats. Attach cod lines 15 feet in length to nose and tail frame. Sink the torpedo 10 feet by lead weights on a cord encircling the shell in transverse plane of center of buoyancy. If air bubbles rise to the surface their position defines the place of leakage.

Note the buoyancy and lines of flotation, then hoist the torpedo on board.

When ready to load in the launching tube, screw in the depth register and place the phosphide of calcium in its pocket, both ends of can punctured. Finally lubricate the outside of shell and trunnion guides.

IMPORTANT FEATURES OF THE HOWELL.

In defining the important features of the Howell in the general classification of the automobile torpedo, one must consider the number of requirements it is called upon to fulfill.

1°—*Concentration in size relative to diameter and length with great strength of shell and rigidity to resist deformation with least possible weight.* The total weight of shell, strengthening and locking rings, is less than 20 per cent. of the loaded torpedo, while the weight of explosive charge is more than 19 per cent.

2°—*Its effective working range as compared with its total weight, being greater than that of any other type with equal displacement.*

3°—*Its capacity to maintain a comparatively uniform speed by virtue of its speed regulator;* the automatic action of its pitch mechanism, being governed by the ratio of decrease of revolutions of the fly-wheel, thereby increases the pitch of the blades correspondingly, which reaches a maximum at the end of its effective working range.

It has also been found that, by compounding the motive power in the present system, the speed is increased over 50 per cent. and the effective working range doubled. Also that similar conditions are obtained with the cylindrical fly-wheel type of increased weight, the maximum capacity of which has not yet been fully determined for a torpedo of 18 inches diameter.

4°—*Capacity to maintain a rectilinear direction in the horizontal plane.* The gyroscopic force of the Howell gives great rigidity against horizontal deflection of the longitudinal axis in a yielding medium within a range of 800 or 1200 yards of the target, when subjected to sudden shocks, as upon impact in launching, or opposing surface currents, which are met with on soundings, and at approaches to all harbors more or less. In the part of this article under which I propose to discuss the question of the Dynamical Effect of Broadside Launching it will be observed that the only effect of the sudden shock due to impact in the keel angle of fire, with vessel at speed, is to slightly roll the Howell on its longitudinal axis with a sudden motion, having only the fraction of a second of duration.

This action places the Howell in a new gyroscopic plane at a fixed angle with the original until the motion of the vertical pendulum, which swings transversely immediately when its horizontal plane is disturbed, brings into full action the impulses of the vertical rudders.

These impulses become repeated shocks applied in the opposite direction to the original and continue until the vertical pendulum is again horizontal, likewise the torpedo.

It will be readily seen that the action of rolling gives to one of the components of force in the diving rudder a horizontal steering power.

In practice it is found in keel angle of fire, at speed of vessel, that the automatic action of the vertical rudders to right the torpedo is so rapid and effective as to counteract the horizontal force imparted to the diving rudders by rolling; therefore horizontal deviation due to rolling motion is practically eliminated within the effective range. Besides, the rotating forces of the twin screws of the Howell

mounted on parallel shafts act in opposite directions in their revolving planes, and consequently balance themselves, to all practical purposes. Hence there is no necessity for readjustment of vertical rudders for any change in the speed of the vessel, or keel angle of fire, after loading the torpedo in the tube and waiting for the object to come within its effective range.

5°—*Capacity to maintain a set depth at any speed within its maximum range.* As the motive force of the Howell is stored in the fly-wheel during its flight, its weight is always constant, and therefore does not decrease, like other types of automobiles; consequently unlike them it is not subject to the same disturbing forces induced by loss of weight which changes the position of center of gravity and center of buoyancy.

These variations produce errors more or less in a horizontal rectilinear direction, or constancy of depth.

The Howell, however, maintains a comparatively uniform depth at any speed throughout its maximum range.

6°—*Sensibility of the immersion regulator to control the torpedo at a set depth.* The degree of sensibility of the immersion regulator to control the torpedo at any depth is increased when the friction of the hydrostatic piston is reduced to a minimum. It therefore approaches the acme of perfection when reduced to the frictional bearing of the pressure piston only; this to become constant under any movement of pendulum or piston in opening the pathway to a motive power which in turn actuates the horizontal rudder. The angle guide and pallet turn without appreciable effort as they are nicely balanced on their pivots, and with the light pressure piston rod produce the only friction or work in the motion performed by the piston and pendulum in defining the angle of the guide at each instant.

This holds good whether the combined effects of the pendulum and piston are in conjunction or opposition, or otherwise acting independently, one of the other, in transmitting the angle which is given to the angle guide.

The angular throw of the horizontal rudder varies directly with its pallet and becomes a series of elastic impulses per second, in which the intensity of its effective force is governed by the angle transmitted through the angle guide and its pallet to the impulse rack.

DYNAMICAL EFFECT OF BROADSIDE LAUNCHING WITH VESSEL AT SPEED.

In reviewing the practice with the automobile by foreign countries it is found that no attempt has been made to determine a practical solution of the dynamics of broadside launching with the vessel at speed. All efforts in this direction, however, have failed to produce any reliable data whereby efficiency has been increased beyond bow and stern launching.

It is very evident that there must be some recognized law upon which the dynamics of broadside launching should be founded. From the nature of the automobile the dynamical effect of disturbing forces becomes apparent at initial dive and influences the accuracy of its flight to a greater or less extent. Under these conditions it follows that there must be developed in the automobile a controlling force which will produce rigidity in the longitudinal axis against angular deviation in the horizontal plane. These conditions are fulfilled in the Howell by the directive force generated in the plane of the longitudinal axis through the gyroscopic motion of the fly-wheel. Under these conditions the dynamical effect at initial dive is brought within the range of experimental determination.

Having witnessed several hundred shots with the remodeled Howell under all conditions of weather and temperature, in which I kept a complete record of all adjustments for each run, and results produced in the torpedoes as affecting immersion and accuracy of direction in the horizontal plane, I was led to make a series of experiments in order to determine the *dynamical effect* of broadside launching and the method to be adopted to counteract it.

The apparatus employed consisted of one of the fly-wheels assembled in its wheel frame with bevel gears and driving shafts attached. The wheel frame was mounted in a ring (1, Fig. 11) so as to revolve freely in the vertical plane of the axis of the wheel (Fig. 13). This ring was mounted on a standard (2) having a circular base (3) free to revolve in a horizontal plane about the center of gravity of the fly-wheel. Both ring and standard revolved in ball bearing cases so as to reduce the friction of the whole mount to a minimum. A lever (4, Fig. 11) attached to the standard ring and representing the after body of the torpedo, in its longitudinal axis, was also free to revolve in the horizontal plane. A series of blows was applied to this lever at a distance of 5.3 feet from the center of gravity of fly-wheel at a point

which represents the position of the vertical rudders on the torpedo. The number of blows for each series was ten; they were also of equal force for each series, instantaneous, and at equal intervals of time, and made to represent the shock produced on impact at initial dive.

A steam motor, mounted on a separate standard which was stationary, connected with the axis of the fly-wheel by the usual clutch, and admitted of being attached and detached at will.

The action was as follows: With the motor attached to the fly-wheel, the latter was spun up to the number of revolutions desired, and the motor then detached, the ring and standard released, thus leaving the wheel free to revolve in the vertical plane of its axis, and the standard in the horizontal plane. Successive blows were then applied horizontally, at right angles to the lever, and their force measured by a pressure gauge. The result produced upon the fly-wheel was a rolling motion about the longitudinal axis of the torpedo.

Further, when the force (P, Fig. 12) was applied on the starboard side of the tail (4), the torpedo rolled to starboard (R, Fig. 13). When applied on the port side of the lever (P_1, Fig. 12), the torpedo rolled to port (R_1, Fig. 13).

Starting with 2500 revolutions, it was found that ten successive blows, each having a force of 2 pounds, rolled the torpedo 10.25°, or an average of 1° 1′ 30″ roll for each blow.

With 4500 revolutions it required a force of 4 pounds to roll the torpedo 1°.

At 6500 revolutions 6 pounds produced a roll of 1°.

At 8500 revolutions, for 1° roll, the force of the blow was 8 pounds, and at 10,500 revolutions, for 1° roll, 10 pounds.

Hence the force varies with the revolutions in an arithmetical progression.

Determination of the Intensity of Directive Force for an Average of 1° Roll of Torpedo. July 12, 13, 1891.

Lieut. F. J. DRAKE, *Observer.*

Revolutions	2500		4500		6500		8500		10500	
Force.....	2 Pounds.		4 Pounds.		6 Pounds.		8 Pounds.		10 Pounds.	
	DEGREES OF ROLL.									
Number of successive blows.	Starboard.	Port.	Starboard.	Port.	Starboard.	Port.	Starboard.	Port.	Starboard.	Port.
1	1°.25	1°.	1°.	1°.	0°.75	1°.	1°.	1°.	1°.	1°.
2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
3	1.	1.	1.	1.	1.25	1.	1.	1.	1.	1.
4	0.75	1.	1.	1.	1.	1.	1.	0.75	1.	0.75
5	1.	0.75	1.	1.	1.	0.75	1.	1.25	1.	1.
6	1.	1.25	1.25	1.	1.	1.	1.	1.	1.	1.25
7	0.75	1.25	1.	1.	1.25	1.25	1.	1.	1.	1.
8	1.25	1.	1.25	1.	0.75	1.	1.	1.	0.75	1.
9	1.	1.	0.75	1.	1.	1.	1.	1.	1.	1.25
10	1.25	1.	1.	1.	1.	1.25	1.	1.	1.25	0.75
Sum.....	10°.25	10°.25	10°.25	10°.	10°.	10°.25	10°.	10°.	10°.	10°.
Mean.....	1°.025	1°.025	1°.025	1°.	1°.	1°.025	1°.	1°.	1°.	1°.

Force applied on *port* side of head, the torpedo rolls to *starboard.*
Force applied on *starboard* side of head, the torpedo rolls to *port.*

Demonstration.

The intensity of normal pressure due to direct head resistance at right angle to the course of the vessel at a speed of 20 knots is $\frac{20\times 6080}{60\times 60}=33.777$ feet per second; and $\frac{(33.777)^2}{64.333}=17.73$ feet=height due to a velocity of 33.777.

Then 17.73×64.125 pounds$=1137$ pounds per square foot.

The launching velocity of the torpedo is 41 feet per second.

Time of immersion from tip of nose to center of gravity of torpedo is $\frac{4.34}{41}=0.1059$ second.

The longitudinal sectional area of the torpedo forward of its center of gravity is 4.52 square feet.

The center of effort of this sectional area is 1.98 feet forward of the center of gravity of the torpedo.

The resistance of the convex surface of the torpedo whose sectional area is 4.52 square feet is $\frac{1}{2.3}=0.4348$ of its sectional area.

The resistance of the longitudinal sectional area is $1137 \times 4.52 \times 0.1059 = 544$ pounds; and the resistance on the convex surface is $544 \times 0.4348 = 236.6$ pounds, or $236\,6 \times 1.98 = 468.3$ foot-pounds, exerted at the center of gravity of torpedo.

By table "A," at 10,000 revolutions of fly-wheel, 9.5 pounds $\times$ 5.3 feet, the distance of the center of gravity of the torpedo from the force applied, = 50.4 foot-pounds, required to roll the torpedo 1°.

Then at 20 knots speed of vessel the torpedo will roll $\frac{468.3}{50.4} = 9°\ 18'$, and for speeds under 20 knots, as follows:

At 19 knots	$= 8°\ 45'$.	At 10 knots	$= 3°\ 48'$.
" 18 "	$= 8°\ 12'$.	" 9 "	$= 3°\ 15'$.
" 17 "	$= 7°\ 39'$.	" 8 "	$= 2°\ 42'$.
" 16 "	$= 7°\ 06'$.	" 7 "	$= 2°\ 09'$.
" 15 "	$= 6°\ 33'$.	" 6 "	$= 1°\ 36'$.
" 14 "	$= 6°\ 00'$.	" 5 "	$= 1°\ 03'$.
" 13 "	$= 5°\ 27'$.	" 4 "	$= 30'$.
" 12 "	$= 4°\ 54'$.	" 3 "	$= 00'$.
" 11 "	$= 4°\ 21'$.		

This is the dynamical effect of broadside launching at right angles to the course of vessel.

At an angle with the course the resistance is found to vary with the $\sin^2$ of the keel angle of fire.

Take for example the Philadelphia, which is to be equipped with the Howell broadside tube.

Extreme train forward, 60°.

The resistance is $468.3 \times \sin^2 30° = 117$ foot-pounds. Hence, $\frac{117}{50.4} = 2°\ 19'$ roll of torpedo at 20 knots speed.

The after tubes have an extreme train aft of 17°.

The resistance is $468.3 \times \sin^2 73° = 428.3$ foot-pounds; and $\frac{428.3}{50.4} = 8°\ 30'$ maximum roll at 20 knots speed.

As the torpedo always rolls towards the stern in the vertical plane of fire, the tendency will be to deviate horizontally in range forward of the line of fire. In order to overcome this lateral deviation, I considered the maximum resistance under the following conditions:

First. Moment of resistance of vertical rudder surface per square inch.

The effect of pressure, due to the velocity of the torpedo in the water, upon the vertical rudders acting under impulses, and which forms a couple with resultant force in the longitudinal axis of the torpedo, is to roll it about its axis towards the side on which the rudders act.

The normal intensity of pressure is resolved into two components, viz.: (1) a longitudinal component, $KV^2 \sin^2 \theta$, which is the direct head resistance offered by the rudders when at an angle $\theta = 18°$ with the middle line of the torpedo; (2) $KV^2 \sin^2 \theta \times l \cos \theta$, which gives it a rolling motion.

In Fig. 14, plan view, consider the moment and resistance of the vertical rudders.

K = resistance on one square inch of rudder surface moving perpendicularly to itself at a speed of 1 knot = 0.019782.

V = 23 knots, velocity of torpedo.

$l = RG$ perpendicular from normal RP to center of gravity G.

7° 7° = vertical rudder.

Then the direct head resistance offered by one square inch of rudder surface is $KV^2 \sin^2 \theta$.

In (2), $l \cos \theta = RG$.

M = rolling moment.

V = 23 knots. l = 5.3 feet.

Substituting the values in (2) and solving, $M = 0.019782 \times 529 \times \sin^2 18° \times 5.3 \cos 18° = 5.037$ foot-pounds per square inch

Second. Area of vertical rudders.

The vertical rudders when in action, due to a transverse rolling motion of the torpedo exceeding 2°, produce their maximum effect.

The area of the V. R. must therefore be considered under the conditions which affect the action of the torpedo in a unit of time.

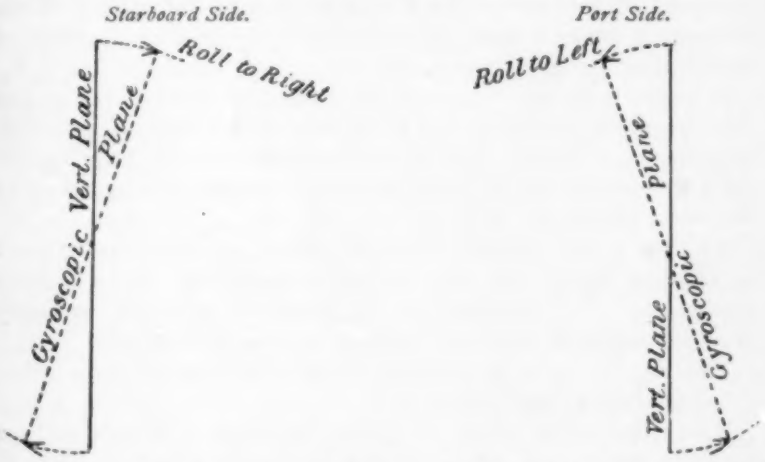
The vertical rudders must also right the torpedo before it shall have covered a distance of 60 feet, or reached its set depth, when launched at a keel angle of 90° with vessel at maximum speed of 20 knots or more.

At this speed the resistance on the convex surface is 468.3 foot-pounds exerted at the center of gravity of the torpedo.

The impulses given to the vertical rudders are 4.5 per second.

Multiplying this by the rolling moment, $M = 5.037$, gives 22.67 foot-pounds for one square inch per second. Hence $\frac{468.3}{22.67} = 20.66$ square inches; which is the area given to the vertical rudders and found to be practically effective.

Therefore the effect produced by the initial dive, under these conditions, is a rolling moment in the Howell and it changes the gyroscopic plane instantly to a given angle with the vertical as determined by the speed of platform, keel angle of fire, and revolutions of flywheel, as shown in the accompanying sketch.



Rectilinear direction in the Whitehead is maintained by means of vertical rudders adjusted, previous to discharge, for speed of vessel and keel angle of fire, and which maintain a constant angle throughout the flight of the torpedo.

The impulse movement in the Howell is such that, for a roll of more than 2°, the vertical rudders give the full throw, and for less than 2° roll the following: viz.,

1° 40′	roll of	torpedo	15°	angular	throw of	V. R.
1° 20′	"	"	12°	"	"	"
1° 00′	"	"	9°	"	"	"
40′	"	"	6°	"	"	"
20′	"	"	3°	"	"	"

Thus with powerful impulses the gyroscopic plane of the torpedo is brought rapidly back towards the vertical until the angular distance between the two is less than 2°, when a continually decreasing impulsive force is exerted until the two planes coincide.

The vertical rudders, being controlled by a vertical pendulum acting in connection with the impulse mechanism, are automatic and act only when the torpedo rotates about its longitudinal axis.

Consequently they require no adjustment for speed or keel angle of fire.

In stationary firing the torpedo will very seldom rotate on its longitudinal axis within its effective range.

It will be possible with the present Howell speed regulator, to give it a speed equal to that of the Whitehead of same caliber, as the pitch mechanism can be adjusted so as to absorb the maximum energy of the fly-wheel in developing speed.

In order to insure the same percentage of directive force and rigidity against rolling in the Whitehead, Schwartzkopf and Hall torpedoes, and thereby increase their efficiency in broadside launching with vessel at speed, the following has been recommended to the Bureau of Ordnance:

To place a fifty pound fly-wheel in each of the above named types of torpedo adopted in our service, independent of its present mechanism. This fly-wheel to be connected with the necessary impulse movement, vertical pendulum, and vertical rudders.

This is to be done by increasing the displacement in the cylindrical section by additional length.

This combination could be launched from a Hotchkiss tube specially constructed, after spinning up the fly-wheel to 8000 or 10,000 revolutions, with the compressed air still acting as motive power for driving the propellers.

This would bring the several types of automobiles into close competition for determining relative efficiency as broadside weapons possessing a maximum capacity for speed, range, immersion, rectilinear direction in the horizontal plane, and rending force.

AUTOMOBILE TORPEDOES IN BROADSIDE LAUNCHING AT SPEED.

A period of seventeen years marks the practical use of the automobile torpedo as a recognized weapon to be used in war.

England, France, Germany and Russia have experimented with the automobile as developed in the Whitehead and Schwartzkopf types with the object of establishing some degree of efficiency in broadside launching.

ABOVE WATER DISCHARGE.

In above water discharge, spoons have been added to the muzzle of the launching tubes extending beyond the side of the vessel sufficiently to give the torpedo a comparatively free drop horizontally. This has been found necessary in order to limit the angle of dive which, in a measure, affects the initial dive.

Besides, automobiles of the Whitehead type, being particularly sensitive to any outward force which disturbs the horizontal equilibrium at the instant of impact, are given as low a velocity of discharge as will insure a free clearance of the tube and spoon.

It is also necessary that the speed of the vessel and the keel angle of fire remain constant for any one discharge, as the vertical rudders are set to fulfill these conditions previous to the launching.

Therefore, any change of speed or course in the heat of action always necessitates readjustment of the vertical rudders, which complicates the efficiency of broadside launching and might possibly result in failure to reach the enemy.

The true automobile torpedo must therefore, of necessity, be of such a type that any change of speed, of platform, or pivoting of launching tube in order to bring the enemy in line of fire, will not retard its action nor affect its accuracy in flight. It must automatically adjust itself to these conditions, and thereby leave the torpedo crew to give their entire attention to keeping the object in range until the instant of launching.

Approaching the enemy, the commander is then prepared to give his vessel the greatest possible speed upon entering the dangerous zone, and use such tactics in manœuvering as may develop the best means of coming within striking distance.

To what extent a loaded torpedo is protected when subject to the rapid fire of B. L. R. and machine guns, depends upon the type of shield employed to protect the muzzle of the tube and the attached war head. One shot safely landed in the nose or upon the detonator would cause the absolute destruction of the torpedo vessel.

Therefore it becomes necessary in above water discharge to protect the tube and torpedo with an oblong shield spherical in shape and of proper thickness to insure the perfect action of the torpedo up to the instant of launching. At the point opposite the muzzle of the launching tube there should be a port buckler in the shape of a revolving elbow nicely balanced, and worked by a powerful lever so

as to drop downward, the action of the elbow to precede that of the firing.

Adjacent launching tubes are to be used so that an attack made upon a vessel at anchor with her torpedo net down will result in launching consecutively two or more torpedoes concentrated upon the same point of attack, and within 2½ or 3 seconds of each other. The launching tubes must be capable of such adjustment as will conform to a maximum speed of vessel at an effective range up to 800 yards at least.

The present launching tube is virtually unprotected against rapid fire.

As it is necessary to protect modern guns with fighting shields in order that their service may be effective, so it is equally necessary to protect the launching tubes of the automobiles and their machinery under similar conditions, if corresponding efficiency is to be developed within their range.

Furthermore, loaded torpedoes cannot be moved about deck in action, hence each launching tube must be loaded previous to an engagement, and therefore absolutely requires a safe protection. The light shields now supposed to be in use are far from fulfilling the object intended. Hence, modern developments point to the need of a permanent protection for launching tubes, by adopting fighting shields of greater weight, and consequently torpedo boats of increased displacement.

UNDER WATER DISCHARGE.

In bow fire the torpedo well is filled and the vessel carries dead water in the channel pipe which extends from the outer skin of the vessel to the muzzle of the tube. Thus, in launching, before the nose of the torpedo is fairly projected from the under water body, the propellers are turning in water, and accelerated speed is produced which, in the motion of translation, enables the torpedo to clear the hull, and almost at the required set depth. Absolute certainty must be given to this discharge, otherwise the commander labors under the fear of never knowing when he may overrun a loaded torpedo, which result might prove disastrous.

A perfect system of electric signals should extend from every launching tube to the fighting towers, which would automatically indicate upon the face of electric dials the instant of discharge as well as the instant the torpedo is clear of the ship's side. This is a matter

easily arranged and always effective in its action. The same system may be employed to discharge a torpedo at the will of the commander, by throwing into action the electric discharge circuit. In broadside launching it is found that the English and French have experimented with every conceivable type, and would have adopted a permanent system had 25 per cent. of their results been successful.

Determined efforts, however, to retain broadside launching virtually eliminated the question of a variable speed, thereby placing a handicap upon the manœuvering qualities of the vessel using the Whitehead type, for the essential feature of self-contained directive power in the type of torpedoes used was found wanting. Consequently, this led to a complication of mechanism in the launching apparatus which assumed such proportions as to become unwieldy and unreliable with a vessel at maximum speed. Hence, in all manœuvers conducted abroad as object lessons, we hear very little relative to the launching of automobile torpedoes from the large cruisers at speed in forcing an attack. This is confined to torpedo boats of light displacement and above water discharge, while armored cruisers and battle-ships acting on the defensive show their alertness in detecting the presence of these torpedo boats, which, if discovered within the dangerous zone, have but a single chance of escaping complete annihilation.

It has also been demonstrated that a vessel going at a speed of 12 knots, with a moderate sea and swell of only 3 or 4 feet from crest to hollow of wave, is comparatively safe from an attack.

This is due to the irregular action produced upon the automobile in its initial dive by sea and swell from an above-water discharge. For, in the drop from muzzle of launching tube, should the torpedo strike the crest of a wave it is almost certain to broach and be deflected by its imperfect submersion at impact.

Besides, the torpedo-boat of low freeboard must move at a speed of at least 16 knots in order to select its position for attack. In so doing, its decks and surface tubes become deluged with water which renders them almost useless. This reduces to a minimum the possibilities of the present low freeboard type of torpedo-boat under 500 tons displacement as effective sea-going craft.

In making an attack they must therefore confine their manœuvers to a smooth sea, a dark night, slow vessels, and these lying at anchor in a harbor without torpedo nets out; for in the event of war, the fast cruisers would be employed at sea and have but little time in port,

and then only for coal, provisions, and such repairs as cannot be made in the fleet under way.

It is evident from a careful study of this subject, and the nature of our coast and harbors and their approaches, that in the beginning we should have a modern torpedo fleet composed of about twenty-five boats of the Cushing type and displacement for the defense of the mouths of our harbors, to act within a radius of 20 miles of their base of supplies. The coast-line should be patroled by 10 torpedo-cruisers of 800 tons displacement and upwards, capable of fighting in a moderate seaway, and self-sustaining for a period of 30 days, with a cruising speed of 12 knots and a maximum of 25 knots, and a radius of action of 9000 miles.

DEGREE OF EFFICIENCY TO BE REACHED WITH THE AUTOMOBILE TORPEDO.

The automobile represents the highest development among naval torpedoes, and is found to possess speed, range, and rending force not to be excelled by any other type of submarine projectile. By virtue of its design it becomes a weapon of offense. In an attack it is opposed by secondary batteries and machine guns. Its ratio of efficiency, therefore, within a fighting range of 800 yards, must compare favorably with that of light ordnance within its range.

In the combination of the automobile, the vessel at speed, the commander in the conning tower, and the torpedo officer at the launching tubes, we have the elements in which the degree of practical efficiency alone can decide the question of an attack. Hence how important it is that in the general service routine every effort should be made by commanding officers of our cruisers equipped with automobiles to carry out rigidly the quarterly exercise with this weapon. Vessels cruising in the vicinity of New York, Boston, Portsmouth, etc., should exercise with automobiles in Gardner's Bay, where extreme ranges can be had and net targets safely anchored. Those cruising south of New York and north of Port Royal to use torpedo grounds in Chesapeake Bay. Those cruising south of Port Royal and in the Gulf to use grounds laid out in the Gulf. These torpedo grounds in home waters for trial runs to be definitely located by the Bureau of Ordnance under the approval of the Secretary of the Navy. Commanding officers of vessels in foreign waters to select and report upon trial grounds wherever they shall be found suitable for the purpose.

The depth of water should be five fathoms at least, with sandy or hard clay bottom; to be as little affected by currents as possible, and laid out with regard to scope for trial runs with the vessel at speed. Then commence trial runs with vessel at anchor, or moored stem and stern so as to lie bow on or broadside to target, as the case may be, with the necessary number of boats out, and such observers as will be specified in the torpedo instructions.

From trials at anchor proceed to trials under steam with vessel comparatively stationary; then to running trials with vessel at speed: making a series of three shots at least from each tube. At first there may be some mishaps and much weariness of spirit; nevertheless this work must be continued, even should it consume one or two weeks of constant attention to complete the series. By these efforts alone shall we be able to reach that degree of efficiency necessary to handle the automobile with success. It will also have its individual effect in fleet tactics wherein battle-ships and armored cruisers moving into position for a night attack, the former accompanied by two or more torpedo cruisers acting directly under the supervision of the commanding officer of the battle-ship, become a unit in which the battle-ship is the base for any and all changes in the tactical evolutions. The torpedo cruisers become scouts for warding off and defeating torpedo attacks which would naturally be made by other torpedo-boats upon the battle-ships.

Should the commander of an armored cruiser or a battle-ship attempt, in the presence of an enemy, to manœuver his vessel with the net out, he at once hampers himself to such an extent that the speed and turning power of his vessel are reduced to less than 50 per cent. He therefore exposes himself to the danger of an attack from a fleet of torpedo-boats which would then take possible chances under the cover of night to place a torpedo regardless of his net defense, the efficiency of which is much reduced by his speed.

One of the most important features, then, in an attack with the automobile is to have some definite means by which the commander may determine the course and speed of the enemy; then will he be able not only to decide his course of action, but the most effective point at which he should enter the dangerous zone.

Three torpedo cruisers of modern construction should advantageously engage an armored cruiser or battle-ship between twilight and early dawn, acting jointly on a preconcerted plan in which three lines of attack should be made simultaneously.

It should be distinctly understood that the essential features of efficiency of the automobile consist in fighting battle-ships and armored cruisers; but the greater the degree of the efficiency of the automobile and the more powerful and impregnable the armored torpedo cruiser which carries it, the more severe are the restrictions it places upon the freedom of action of the battle-ship and armored cruiser when under way. It also lessens their degree of safety when lying at anchor with nets out, and forces unlimited vigilance, which past efficiency of the automobile has not disturbed.

Developments in all types within the last three years will show that it is worse than useless to argue against the future certainty of the automobile to reach a degree of efficiency, within its range, not excelled by any other weapon which is capable of deciding an action with one or two shots.

LINE OF ATTACK.

The safest line of attack which can be made upon a battle-ship or cruiser by two or more armored torpedo vessels, acting conjointly, is that which exposes them to the concentrated fire of the secondary batteries the shortest interval within the dangerous zone; hence the bow and quarter line of attack. As the length of time necessary to handle the heavy guns of the main battery in a seaway is usually more than seven minutes, a greater interval than would be required for the torpedo cruiser to pass through an exposed arc of 135° within the dangerous belt, the probability of a shot from this battery is therefore not considered, owing to the high speed and rapid change of bearing and distance of the torpedo cruiser.

The first evolution of the torpedo cruisers will then consist in taking a beam line of bearing, numbers 1 and 2 on the starboard, and number 3 on his port beam, or *vice versa*, distant not less than five miles.

Second evolution.—Observe his course, note his time, then steam ahead at full speed parallel to the enemy's course until he is brought on a quarter line of bearing distant about 8.5 miles. Then slow down and keep this position until No. 2 torpedo cruiser has taken a bow and quarter line position on Nos. 1 and 3 and ahead of the enemy. (Fig. 15).

Third evolution.—At a given signal from No. 2, Nos. 1 and 3, having observed the enemy's speed, will take a traverse course, such that at full speed they will be brought in contact with the former in the shortest space of time.

No. 2 goes about and steers for the enemy at full speed. If the torpedo cruisers are capable of a 24-knot speed they will arrive within 2000 yards in ten minutes.

In two minutes more they will be within effective range with their torpedoes. Passing astern consecutively on each beam, they will fire first their bow torpedoes, then broadside.

Thus, three attacks can be made in rapid succession and several torpedoes launched, of which one or more should be effective, and this with only six minutes exposure within the dangerous belt. The rapidity of such an onslaught within so brief an interval of time is more than liable to produce a demoralizing effect in the efficient service of secondary batteries.

Any other line of attack necessitates a longer interval of exposure within the effective range, which accordingly diminishes the successful chances of the torpedo cruiser. It will always be found that a successful attack will be combined with a high rate of speed, and consequently a rapid change of position of the attacking party.

No. 2 torpedo-boat, instead of making an attack from directly ahead, could, however, remain astern, and thus cut off the enemy's escape from an engagement by a sudden change of course. By this change in the first evolution, only two of the modern type of torpedo cruisers are brought into action, with the possible launching of six torpedoes by firing both bow tubes consecutively, and then the broadside tube.

Besides, any change of course of the enemy brings him sooner in conflict with No. 2 astern and No. 1, or with No. 2 and No. 3, according as he changes course to port or starboard. On the other hand he may force a single engagement by steaming at full speed for No. 1 or No. 3 on his bow bearing, or No. 2 astern, and thus avoid a simultaneous attack from two or more of the torpedo cruisers. Then it becomes a question of a single torpedo cruiser launching his three torpedoes in the five minutes in which he will be exposed within the dangerous zone.

Under these circumstances the modern armored torpedo cruiser of high speed should be able to withstand effectively the fire of secondary batteries from a battle-ship until within safe striking distance and with chances of winning the fight.

PRESENT EFFICIENCY OF AUTOMOBILE TORPEDOES.

It is claimed by many, laboring under a delusion relative to the principles of the automobile torpedo, that, up to the present, its efficiency is limited to a few spasmodic efforts which do not add to its intrinsic value as a reliable means of under-water attack. It is true that over 98 per cent. of the practical attempts to blow up vessels in war have proved failures. Without stopping to consider this declaration, the casual observer condemns then and there the efficiency of the automobile.

Has it ever occurred to those who assail its efficiency that numerous other conditions surround it? Efficiency in the automobile is not an inherent quality; it is dependent upon a careful and distinct adjustment of all its parts, each to perform its several functions without friction or clashing with its neighbor. Like any delicate piece of machinery constructed of the best material, it must have a skillful and competent director. He must be in harmony with his work and thoroughly acquainted with every detail. As the several bearings, guides, pistons, etc., of an engine are adjusted and lubricated previous to starting, so much more should the several parts of the automobile torpedo. Were it possible to make an investigation and test the accuracy of the adjustments of the torpedoes which have been lost in practice and failed in war service, and of the thoroughness of the system of exercise under the individual torpedo officer, undoubtedly there would be found a want of proficiency in the latter to produce efficiency in the former; and to this cause I should trace nine-tenths of the failures. There is no question that, within its scope, the automobile is efficient when handled intelligently.

The elements of fighting power in the automobile are limited to attacks made upon the under-water body. Hence it becomes necessary to combine in it the highest degree of efficiency in order that it may not be deflected horizontally from its course by any change of its previous condition.

The successful torpedo officer of the future must serve faithfully his apprenticeship to the torpedo by personal contact. He may master the principle of its action in a day, but only long and continued application to the study of every detail of its mechanism will reveal to him its fineness of construction and its delicacy of adjustment. He must see the result of the labor of his own hands in the adjust-

ments made in practice trial runs, and not until then will he begin to comprehend the limit of its sensibility in responding to his manipulation.

The neglect of any one detail in its several adjustments is liable to cause its loss, as it augments an individual eccentricity in the torpedo which destroys the harmony of action in the mechanism.

Following the recent advent of the Howell, it is safe to say that the efficiency of the automobile has been doubled, as it now becomes a weapon capable of automatically correcting the disturbing influences due to a broadside discharge with the vessel at speed. Hence we mark the most important step which has been made in its practical efficiency, and present the torpedo under fighting conditions which, within its range, can be made to equal those of ordnance projectiles.

There is no longer any necessity for slowing down the speed of the vessel in order to discharge an automobile from a bow, stern, central pivot, or broadside tube.

The element of danger which has been found to exist from impact, viz., overrunning the torpedo in bow launching at any speed of vessel, is now entirely overcome, as the Howell is given a launching velocity the rate of which exceeds that of the highest speed attainable in torpedo-boats or cruisers. Neither is there any future necessity for bow launching tubes placed in the plane of the keel and piercing the stem in order to increase their efficiency in a rectilinear direction.

Accuracy of aim in bow fire does not materially affect the result with the tube at an angle of 3° with the line of keel, for the highest efficiency consists in launching at any keel angle of fire regardless of speed of platform.

Granting that the automobile, if properly adjusted, will do its work, then the question of practice follows, in which the officers and men detailed for this service must be trained in an intelligent and practical manner with all of the attendant surroundings in which practice forms the element of efficiency in actual warfare.

To what extent this may be carried will depend upon the individual interest exercised in developing the most effective system of instruction in torpedo practice, and our combined effort to make this arm of the service worthy of the respect and consideration of every commander of a war vessel.

It is not to be inferred from this that a select body of officers and

men should be quartered on shore and go out occasionally in a torpedo-boat when weather permits, to witness two or three shots in a day or an afternoon; neither should it be considered conducive to a proper *esprit de corps* to endeavor to gain a practical knowledge in shore quarters of a weapon purely designed for under-water service afloat. In my opinion there is only one way of reaching this point of efficiency, and that consists in building without further delay at least two sea-going training automobile torpedo-cruisers, each having at least 1500 tons displacement, possessing the highest possible sea speed and greatest possible conveniences for handling and recovering all types of automobiles. In this equipment must be included suitable nets and floats for ranges, and a complete diving outfit for examining the bottom for missing torpedoes. Comfortable quarters for officers and men should be fitted, including a lecture and draughting room, and each ship should have all of the factory appliances for repairing, assembling, adjusting and testing. Order to these vessels such officers and men as will be required in our cruisers to complete their complement in the torpedo outfit.

Select three cruising and practice grounds, one south, in the Gulf for winter work, the second in Chesapeake Bay, and the other north for summer work. These vessels to repair to their stations according to the season; to go to the practice grounds and there remain five days out of the week, engaged in a system of routine exercises in dismounting, assembling, adjusting and firing, with vessel moored, then stationary, and finally at speed. In this practice, projections of the curve of flight to be drawn to natural scale, from which lectures and discussions will be made relative to the result of the adjustments for each individual run. A complete record of this work to be forwarded to the Bureau of Ordnance for future reference in comparing the action of automobiles in general service, and to form the base for future instruction in the post-graduate course at the War College and Torpedo Station for commanding officers and others who hold the interest of a progressive torpedo service paramount to ordinary routine duty.

After three or four months of such active service, each officer under instruction to deliver a theme setting forth his views, impressions and explanation of such improvements in service practice as may be suggestive of points attaining to higher efficiency.

The men under instruction to be subjected to a rigid examination relative to all practical elements. The whole to become a part of the Bureau's record.

After completing this course, the officers and men to be relieved by others and ordered to the different cruisers having automobile torpedoes as a part of their outfit.

We shall then have in service a corps of officers and men educated up to a practical standard of proficiency, who understand thoroughly the usefulness of this weapon, and are capable of developing with it some degree of efficiency worthy of the name. Therefore action should be taken to bring before the Secretary of the Navy the necessity for two such cruisers to be contracted for and built without delay. For the present emergency, equip the Vesuvius and gunboat Machias with a complete outfit of automobile torpedoes and the necessary appliances for repairing, recovering, adjusting, etc., and have them enter upon this duty at once. In the place of the present main battery of the Machias mount broadside tubes. In the case of the Vesuvius mount 3 tubes in each broadside. With these two vessels we have at once the necessary conditions of speed limits from 14 knots up to 20, for a complete broadside practice.

The Cushing and torpedo-boat No. 2 should be connected with this work for the necessary demonstrations in bow launching at different speeds, and other conditions which are more easily exemplified in the smaller type of torpedo vessels. General efficiency in the service will be promoted by such action, and the expense incurred in this temporary outfit, until regular vessels are completed for this special service, will be more than compensated for by the advantages and practical knowledge which will be gained. Further, such action will undoubtedly save to the service the loss of many torpedoes, as well as our reputation for efficiency in the first attempts made to handle new combinations with which all connected are more or less ignorant.

I see no other way out of the groove into which other nations have settled after having introduced automobile torpedoes into their services. If the heads of the departments are slow to act in this matter we must put up with the consequences and console ourselves with the humiliating condition accepted by other countries, namely, possession of one of the most important weapons of warfare without any real knowledge of its possible efficiency.

If we intend to take hold of the automobile torpedo let us do so in a reasonable and intelligent manner, and not stop where we begin. Let us guard against over-confidence in our ability to rise to the emergency when called into action, only to discover our inefficiency when the test comes.

PROBABLE TYPE OF FUTURE TORPEDO CRUISER AND DESTROYER.

Having reviewed somewhat the present development in the automobile torpedo, and the probable efficiency which will be reached in its new departure, there must necessarily follow an equally progressive move in the construction of a modern type of torpedo cruiser (Fig. 16). This vessel must not only possess the qualities of a good sea-going craft, but have a maximum speed of 24 knots. The general dimensions are 300 feet length, 40 feet beam, and 14 feet mean draught; displacement about 2000 tons. The general design of the vessel is upon the longitudinal and bracket system, with an inner bottom extending from the forward collision bulkhead to the stern. The space between outer and inner skins is to be divided by the frames into water-tight compartments.

PROTECTIVE DECK (Fig. 17).

The protective deck will curve downwards at the sides to three feet below the load water line. The flat or crown will be one foot above the load water plane. This deck will have an under plating of one-half inch steel, on which will be worked the protective deck plates. The outside strake of the deck plates is to be five inches in thickness, the next strake inboard to taper in thickness from five to three inches, the third strake to taper in thickness from three to two and one-half inches, the remainder of deck to be two and one-half inches, not including the lower course of plating. All hatches through this deck will have battle plates; the smoke pipes and ventilators will have inclined armor plating of five inches thickness.

CONNING TOWERS (Fig. 16).

The conning towers are to be two in number; one, forward, of 12 inches thickness of steel plates, the after one to be of 10 inches thickness. From these the movements of the vessel will be directed in action. They will be built in the superstructure, elevated sufficiently to give an all-round view, and supported from the protective deck. They will be elliptical in shape, and their greatest dimensions will be eight feet by six feet. An armored tube five inches thick will run from each tower to the armored deck to protect the steering gear, speaking tubes, signal wires, etc. In addition to the armored conning towers there will be a deck house fitted with chart tables, speaking

tubes, steam steering wheels, etc., for use when not in action. All bulkheads below the protective deck are to be water-tight.

The hull above this deck will be of light construction and given to the arrangement of quarters for officers and men and the stowage of provisions. The principal coal bunker capacity will be under the protective deck. Temporary cruising coal bunkers above the protective deck around and over the engines and boiler space will deliver coal by gravity process to the fire rooms through hatches, which will be closed when going into action. A perfect system of artificial ventilation will be supplied for that portion of the hull under the armored deck; communication to be had with all parts by ducts leading to blowers. The vitiated air will be withdrawn by the fans used to force combustion. The explosive gases of the coal bunkers under protective deck will be drawn into the funnel casings, and fresh air pipes lead to the conning towers. The pumping and drainage system will be complete, and every compartment connected with powerful steam and hand pumps.

The ship will be lighted by electricity having duplicate plants. The dynamos will supply power for internal illumination, side lights, head lights, coal bunker lights, and lights in magazines and torpedo compartments. Two powerful search lights will be fitted, for tracing other torpedo vessels, etc., or to aid in the navigation of intricate channels.

The engines and boilers will be below the protective deck. In the arrangement of boilers, longitudinal and transverse bulkheads will be fitted with the best system of forced draught; this will divide the boilers into compartments in pairs, thereby affording greater protection to the machinery and making the boilers less vulnerable to attacks from B. L. R. and machine guns. The engines will be of the triple expansion vertical inverted type, with four cylinders, and capable of developing 9000 horse power, or sufficient to give the speed of 24 knots required. They will be duplicate, each placed in a water-tight compartment, and shafts parallel. There should be 26 water-tight compartments below the protective deck in the division of torpedo rooms, magazines, boilers, coal bunkers and engines.

LAUNCHING TUBES (Fig. 18).

The chief feature of this vessel will be the torpedo armament, which will consist of four under-water 18″ discharge tubes, each placed in a water-tight compartment under the protective deck.

Two bow tubes are parallel to the line of keel, each tube four feet from the middle line and separated transversely by a longitudinal middle line bulkhead; the channel pipes leading to the muzzle of these tubes to have their outer ends square and projecting three inches from the outer skin of hull.

The starboard (forward) broadside tube has a horizontal train through an arc of 75° from 60° forward of the beam. The compartments for these tubes occupy the space forward of the forward boiler-room bulkhead.

The port (after) broadside tube has a horizontal train through an arc of 75°, from 45° forward of the beam to 30° abaft the beam.

TORPEDO MAGAZINES.

The forward magazine is located between the bow tubes and broadside compartment, and is accessible from this compartment through water-tight doors.

The after magazine is immediately abaft the after torpedo compartments and accessible through water-tight doors in bulkheads.

ORDNANCE MAGAZINES.

The magazines for rapid fire and machine guns are located under the protective deck; the ammunition to be served through armored tubes of five inches thickness, extending to the upper deck with the electric hoist, and the magazines to be accessible through water-tight doors in the torpedo magazine passages forward and aft.

TORPEDOES.

The torpedoes will be stowed in racks in each torpedo compartment, and loaded in the tubes by means of a torpedo car running from the racks to loading position of the tubes; the car to run by a gearing and crank, so as to be under the control of one man, regardless of any motion of the vessel.

The appliances necessary in preparing torpedoes for launching are in a separate compartment adjacent to the torpedo rooms, and accessible through water-tight doors. Two plants will be required for this purpose, one for serving forward tubes, the other for after tubes.

A general repair shop for the battery and torpedoes will be located between the forward fire-room bulkhead and after broadside launching-tube bulkhead.

MOUNT FOR LAUNCHING TUBES (Fig. 19).

The broadside tubes will be mounted on training carriages with the muzzle in a ball-and-socket, water-tight joint, trap, and well in the apex of the water channel. The carriages will train by means of worm gear and ratchet. The deck circles are to be graduated, every five degrees to close a circuit which will be recorded on a dial in the conning towers. Circuits for firing and indicating when the torpedo is clear of the hull, are to be fitted also.

BROADSIDE WATER CHANNELS.

The broadside water channels are of peculiar shape. The forward one in a longitudinal sectional view is oblong in shape, about 30 feet in length and 3 feet in vertical width as measured on the outer skin of the under-water body. On this outline a flat wedge with rounded corners is cut out horizontally in the side, the apex ending in a circle of 20″ diameter, and 16 feet inboard from the outer skin measured horizontally in a transverse section of the hull. (Figs. 16, 18, and 19.)

The transverse section of the hull intersects this aperture in the diameter of the 20″ circle, which forms the muzzle of the launching tube with its ball-and-socket joint.

The forward edge of this wedge-shaped water channel is at an angle of 65° horizontally with the transverse section, and admits of launching a torpedo with a train forward of 60° also.

The after edge has an angle of 25° with the transverse section, and allows for 15° abaft the beam as an angle of fire, and the set of the torpedo aft in passing from the water channel which is carrying dead water having the velocity of the ship to the live water outside. (Fig. 19.)

The after channel is also wedge-shaped, the forward edge making an angle of 45° forward of the transverse section which intersects the apex. The after edge is 45° abaft the transverse section, which gives a train of tube for launching from 45° forward of the beam to 30° abaft the beam.

The upper face of the forward water channel is inclined upward 2° from the apex at the muzzle of the tube, to the outer skin. The lower face is inclined downward 5°. In the after water channel the upper face is inclined upward 5°, the lower face downward 5° from the apex to the outer skin.

With the vessel at a maximum speed of 24 knots and the launching velocity of torpedo of 41 feet per second, the set towards the stern will be found to be about five feet in order to clear the ship's side. The torpedo entering the water channel from the muzzle of the launching tube at a speed of 41 feet per second becomes wholly immersed in dead water with its propellers revolving, and acquires an accelerated velocity immediately in passing from this dead water in the channel through the eddy into the live water outside. The water being a yielding medium, the effect produced upon the torpedo is similar to that of an opposing surface in the line of flight, set at an angle equal to the resultant of speed of vessel and torpedo, and acting about the center of gravity of the latter. The ratio of the length of the torpedo to its velocity defines the width of the resultant as an opposing surface, which gives the horizontal deflection parallel to the original line of fire.

Were the muzzle of the tube flush with the outer skin of the under-water body, the moment that the torpedo commenced to leave the tube it would be violently swept aft, and jam the torpedo in the tube unless a guide bar were used as in the Whitehead under-water discharge.

The dead water in the channel pipe, however, having the same velocity as the vessel and a pressure due to the speed, is comparatively still water, and takes the place of the guide bar without its faults.

The torpedo entering this water entirely clears the muzzle of the tube before the nose comes in contact with the live water outside. In addition the torpedo also rolls slightly, which is immediately corrected by the automatic action of the vertical pendulum and rudders, as set forth in the section on the Dynamical Effect of Broadside Launching. These conditions refer only to automobiles having directive force.

A vessel thus equipped has a train for broadside launching through an arc of 75°.

The two bow tubes being parallel with the keel are favorable for any condition of making an attack bows on.

The water channels leading to the muzzles of the launching tubes are four feet below the lower edge of the protective deck and always in still water.

The torpedo is therefore the least affected in launching by any rolling motion of the vessel.

The intercepted frames in the broadside water channels are supported by a network of inside girders longitudinally placed and riveted to the continuous frames at each end of the channel.

Therefore, efficient range of the automobile under the above conditions is not limited to a rigid mount, having only a direct keel line of fire similar to the detachable ram, or submarine gun, or Vesuvius type of aerial projectiles.

Neither does its velocity, directive force and range depend upon its velocity of discharge.

Hence, if efficiency consists in constructing vessels for the purpose of carrying a weapon whose accuracy of aim is wholly dependent upon the skill exercised in *steering the vessel*, how much greater the necessity to construct a type of vessel to carry the automobile which possesses directive, as well as propulsive, force and is capable of any keel angle of fire, regardless of the course and speed of the vessel. Consequently this type of vessel would be able to make an attack in a seaway at speed when it would be impossible to launch a torpedo from a surface tube under any conditions whatever. Also, the efficiency of the vessel as a torpedo platform is greater than that of a cruiser as a gun platform, manœuvering under similar conditions of weather.

The accuracy of flight of the torpedo is affected only by the swell, and the initial dive becomes a minimum, as the torpedo will be launched at least 7 feet under the load water plane and near its set depth.

A vessel of this type would, without doubt, be one of the highest efficiency. The protective deck would be capable of resisting nine-tenths, if not all, of the shots that could possibly strike it from a secondary battery, which otherwise would pierce the hull below the water line.

Her great speed gives great manœuvering capacity, which will stimulate her commander to choose at will the best possible conditions for an attack. In the present development of torpedo-boats the possibility of chances in making a successful attack are very few, in consequence of limited speed in any seaway; besides, the punishment they would now receive from rapid-fire guns, if discovered, means absolute destruction. Hence they must seek the cover of night for any possible protection, with the above-named restrictions added. Whereas the modern torpedo-cruiser as outlined almost reverses the above conditions, and insures success for the automobile

as an offensive weapon which must absolutely be recognized by every commander.

From a careful study of the subject I can see only one other condition under which the automobile torpedo could possibly reach that degree of efficiency which must be obtained in order to compare favorably within its range in offensive action with secondary batteries; viz., to place all the broadside launching tubes upon a disappearing mount for the above-water discharge. Each tube would then be mounted upon a revolving platform *under* the protective deck; a spherical turret cap 4 inches thick revolving with the platform and directly over it would project above the protective deck sufficiently to admit of the rise of the launching tube for discharge. The port in the cap would be shaped to the muzzle of the tube, and would open and close automatically by the action of the mount in rising and disappearing. The sloping barbettes in which the turret caps rest and revolve would be 5 inches in thickness and bolted to the protective deck. The two bow launching tubes would remain as under-water discharge. The barbettes would extend to the sides above the protective deck, and the superstructure be built to them.

In action the superstructure may then be shot away and not interfere with the working of the disappearing mounts or the launching of torpedoes. The loading of the torpedo in the tube should be capable of execution from any point of its train when the mount is down and the tube resting on the platform.

The tube is trained to the desired angle of fire by revolving the platform on which the disappearing mount is located. The mount works independently of the revolving action of its platform; the mechanism being such that the tube may be raised or lowered while the platform is revolving. The whole action of loading a tube, training the platform, and elevating the tube for firing may be done by steam or hand gearing and a crew of six men.

It will be observed that with this arrangement for *above-water* discharge the chances for exploding a loaded torpedo, or destroying the launching butt mount with shots from a secondary battery, are reduced to a minimum.

Only by this, or a similar radical change in the present type of torpedo-boats and torpedo-cruisers, will any practical degree of efficiency ever be reached.

RUNNING TRIALS WITH THE HOWELL.

Figures 20, 21, and 22 are views illustrating the efficiency of an automobile possessing directive force through the gyroscopic motion of its fly-wheel, thereby insuring accuracy in bow and broadside launching with vessel at speed.

These views are copyrighted photographs of the Stiletto at full speed making trial runs with the Howell in Mackerel Cove. They were taken by Mr. Frank H. Child, photographer, No. 242 Thames Street, Newport, R. I., to whom I am indebted for the privilege of publishing these views in the NAVAL INSTITUTE PROCEEDINGS.

The Stiletto is equipped with one bow tube, and one central pivot tube mounted aft on deck having an all-around train.

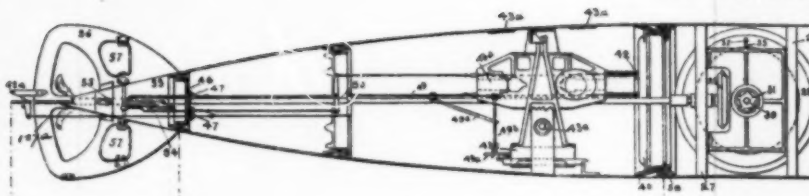
Fig. 20 represents bow launching at full speed, on range with a net target placed at 400 yards. The record shows: "Set depth 10 feet. Buoyancy, 8 pounds. Velocity of Stiletto, 32 feet per second. Muzzle velocity, 42 feet per second. Initial dive, 13 feet. Struck net at depth of 11 feet. No horizontal deviation. Choppy sea and swell setting in from south. Torpedo came to surface in line of fire at a maximum range of 800 yards."

Figs. 21 and 22 represent two views, with an interval of about one-seventh part of a second, of the same discharge from the central pivot tube; keel angle of fire, 90°. These are good illustrations of the torpedo's flight from the muzzle of launching tube to impact, and demonstrate the following conditions, viz.: "Height of axis of launching tube above water, 6′ 7″. With center of gravity of torpedo at 9′ 7″ from muzzle of tube, angle of inclination of torpedo axis below axis of tube, 5°. Drop of torpedo, 1′ 3″. Horizontal distance of center of gravity of torpedo, at impact, from muzzle of launching tube, 19 feet. Inclination of axis of torpedo to horizontal, 16°. Initial dive, 20 feet. Set depth, 10 feet. Velocity of Stiletto, 31 feet per second. Muzzle velocity of discharge, 42 feet per second. Torpedo apparently not deflected, as it came to the surface at the end of its range in the prolongation of its line of fire."

The trials of the Howell torpedoes have been conducted in Mackerel Cove, located at the south end of Conanicut Island at the entrance to the harbor of Newport. This cove is open due south to the full swell of the Atlantic. It is about 1¼ miles in length and ½ mile in width. The middle bottom on the range of trial grounds is of hard sand. The shore line is rocky and steep in

places. The cove shoals gradually from the mouth to its head. Usually a ground swell and sea sets into this cove, which is greatly influenced by weather outside. Hence the majority of trial runs of the Howell have been made in live water under conditions of weather similar to those that will be encountered in actual service.

FIG. 1
ELEVATIO



PLAN

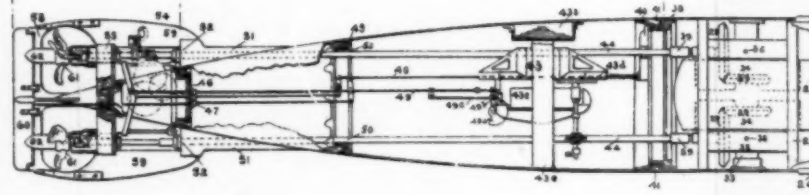
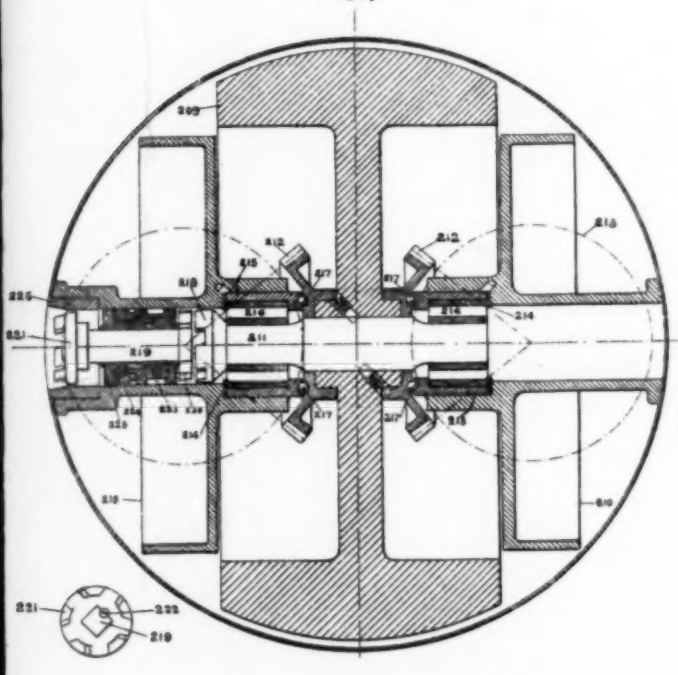
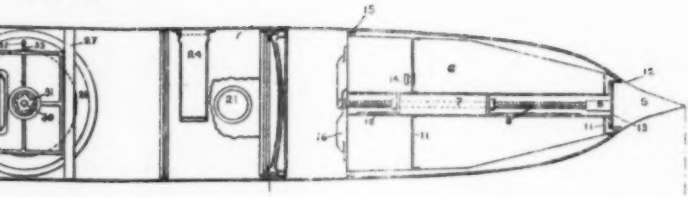


FIG. 1a



FLY WHEEL AND CLUTCH

FIG. 1
VATION



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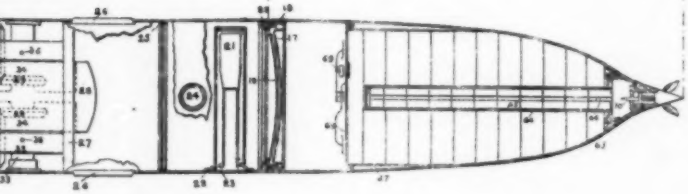
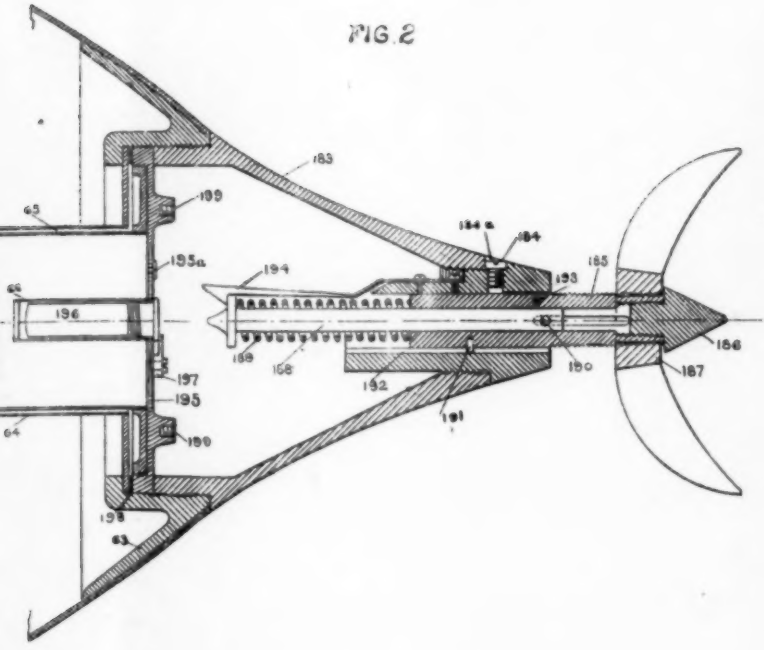


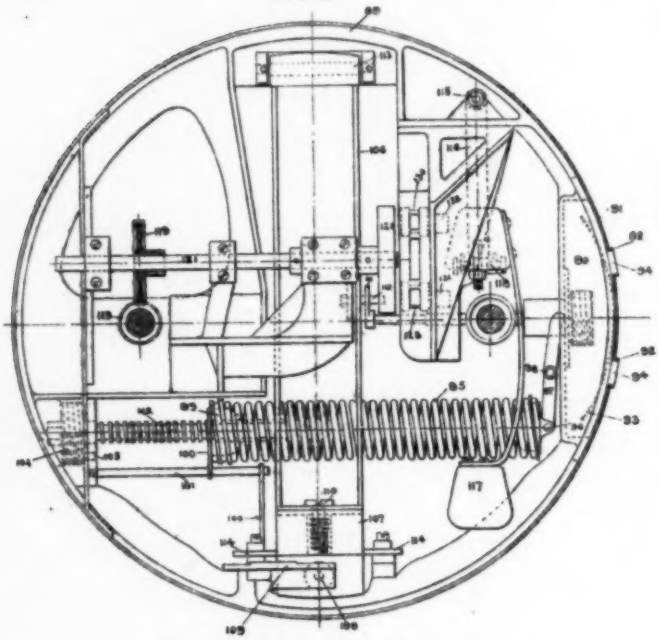
FIG. 2



FIRING PIN

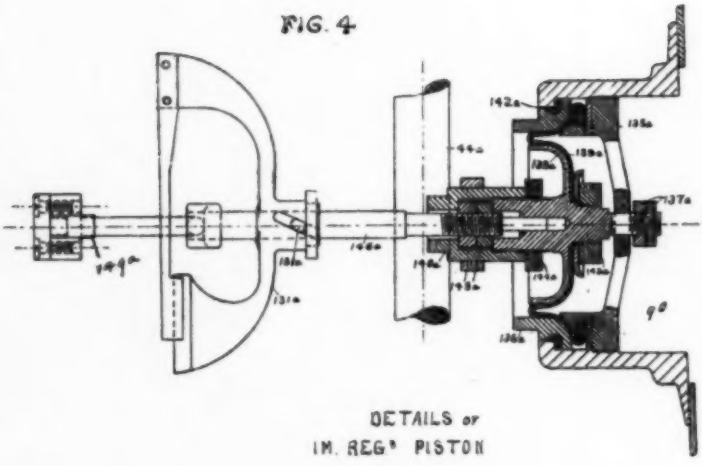
CROSS SECTION

FIG. 3



IMMERSION REGULATOR

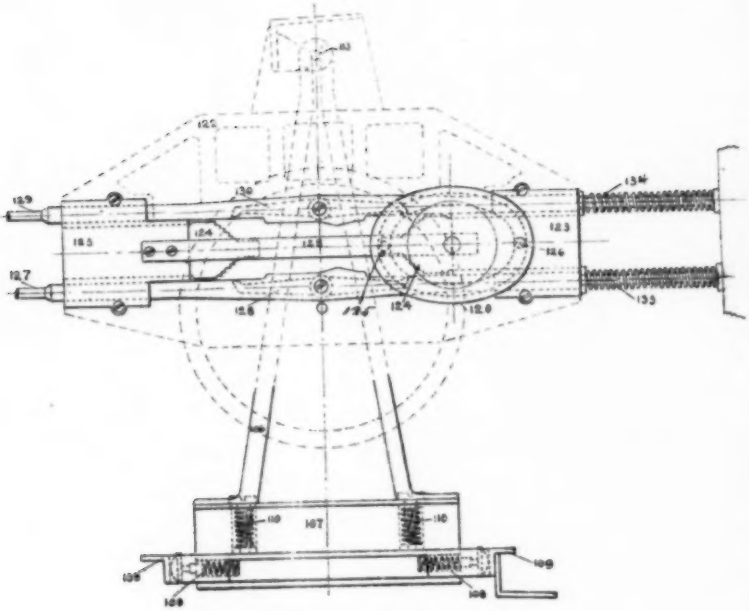
FIG. 4



DETAILS OF
IM. REG^{R} PISTON
MODEL 1892.

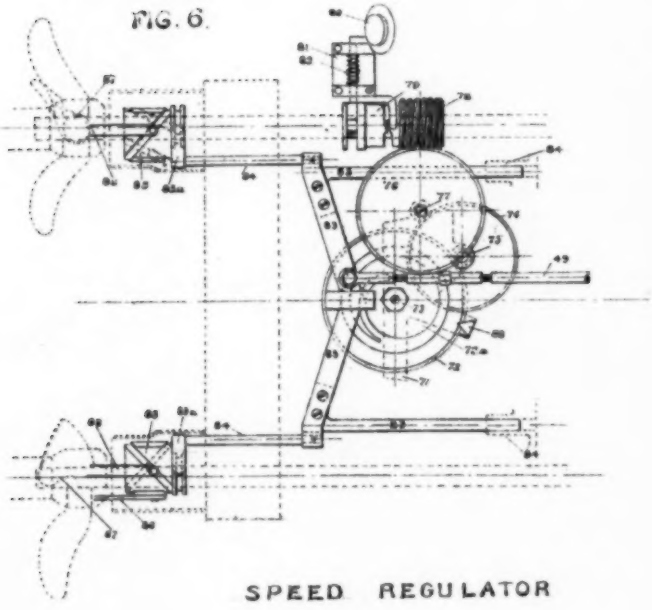
ELEVATION

FIG. 5



IMMERSION REGULATOR

FIG. 6.



SPEED REGULATOR

Fig. 7.

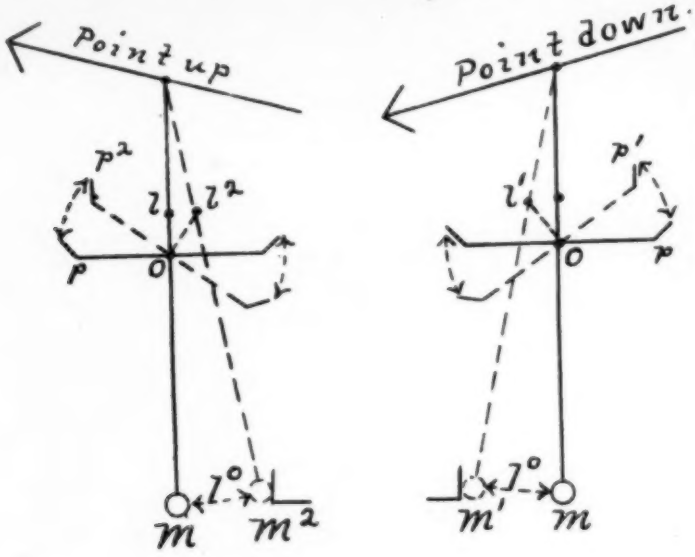


Fig. 9

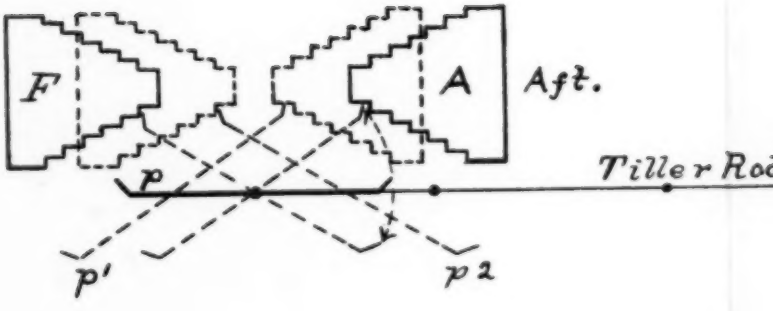


Fig. 10.

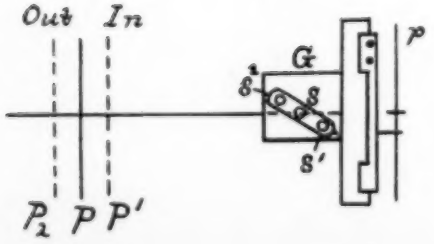


Fig. 8.

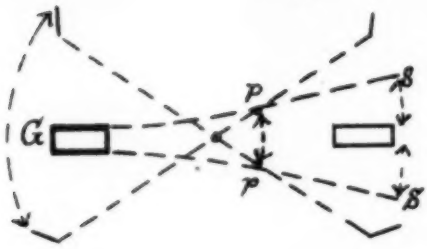
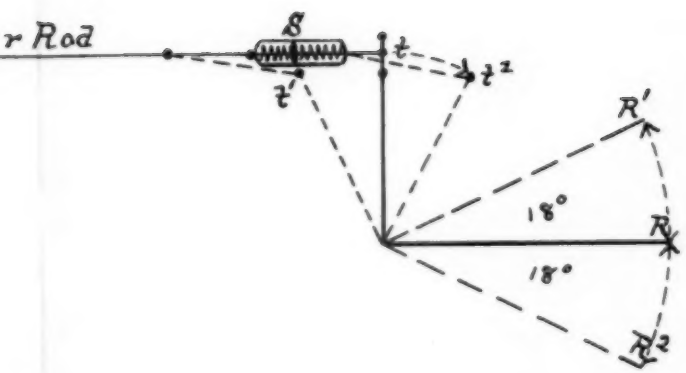
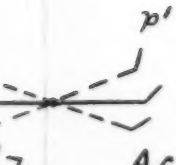


Fig. 9.





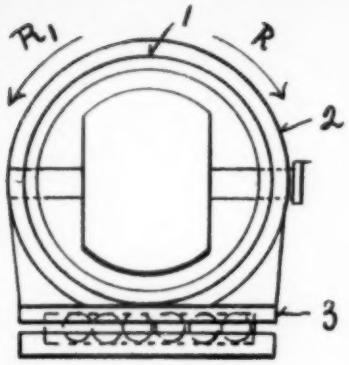


Fig. 13.

Fig. 14

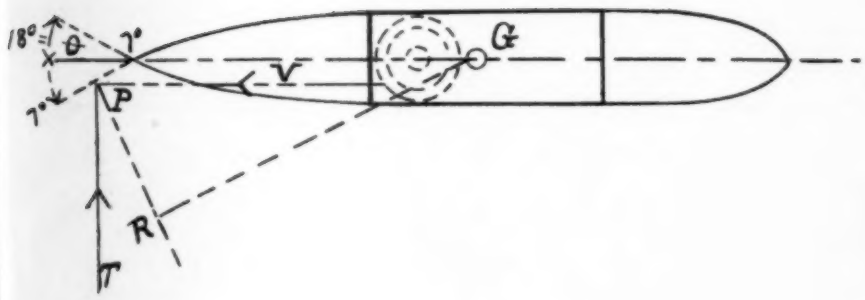


Fig. 15

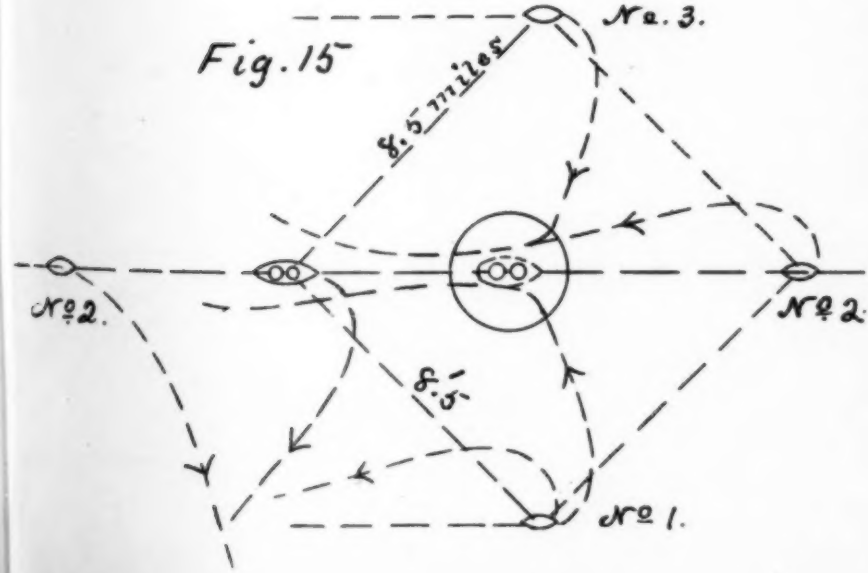
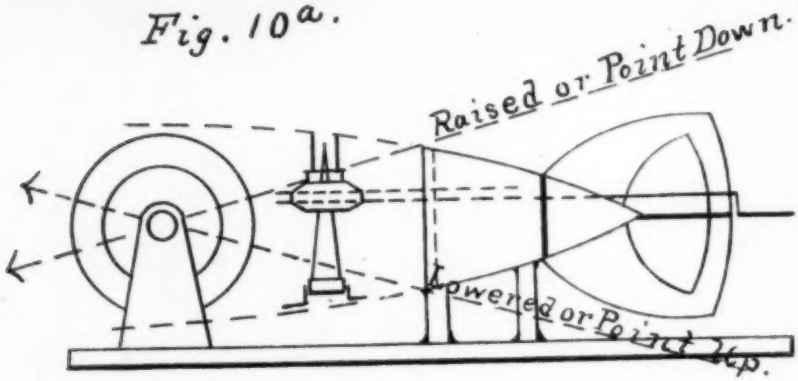


Fig. 10a.



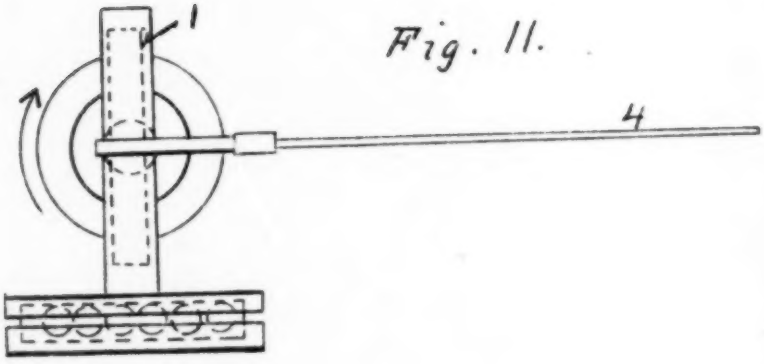


Fig. 11.

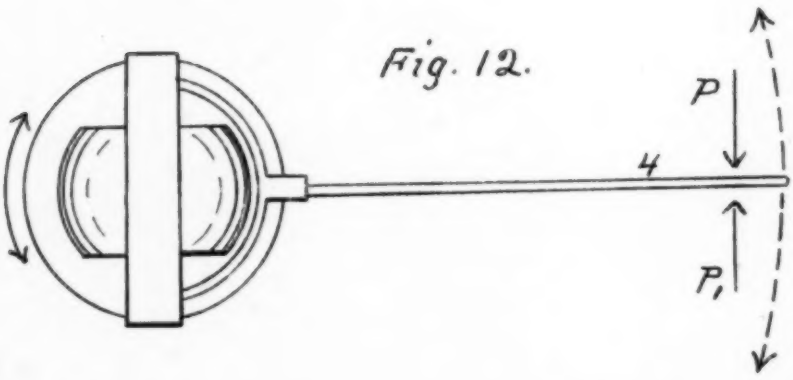


Fig. 12.

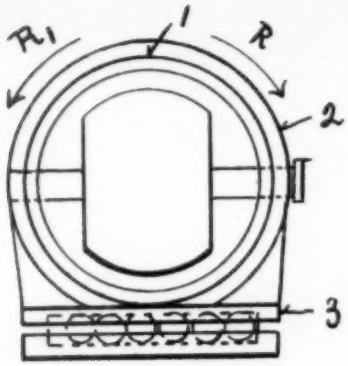
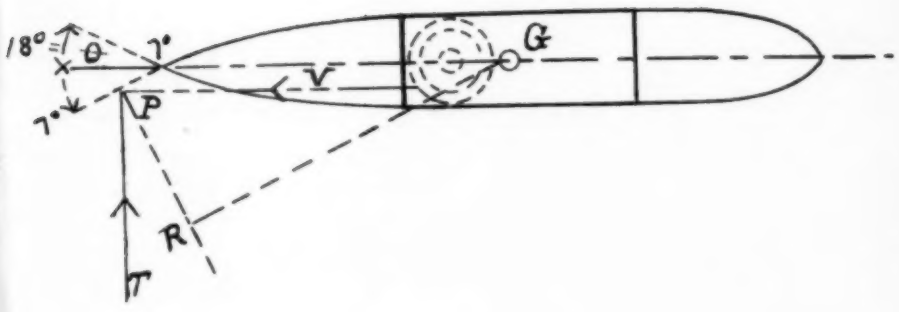


Fig. 13.

Fig. 14



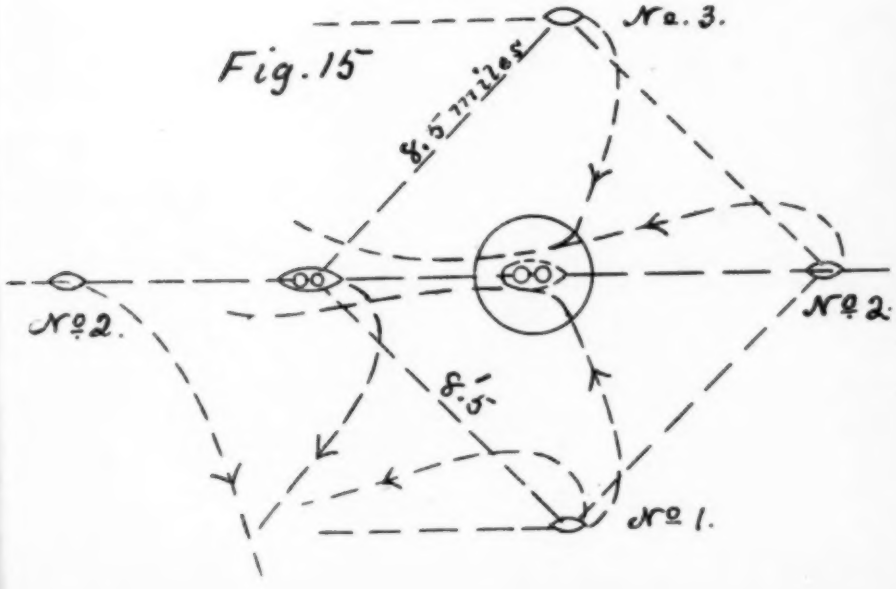
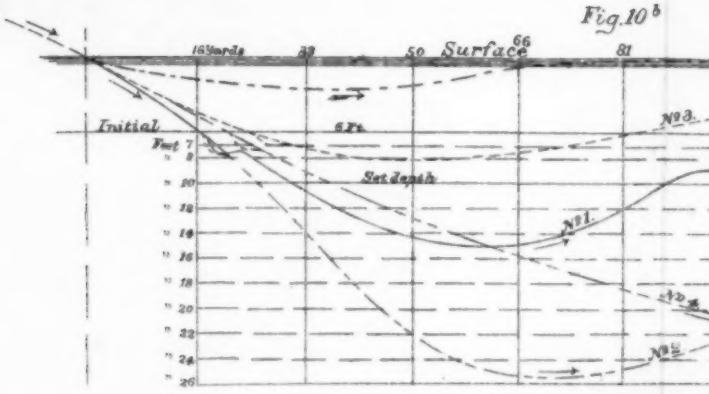


Fig. 15

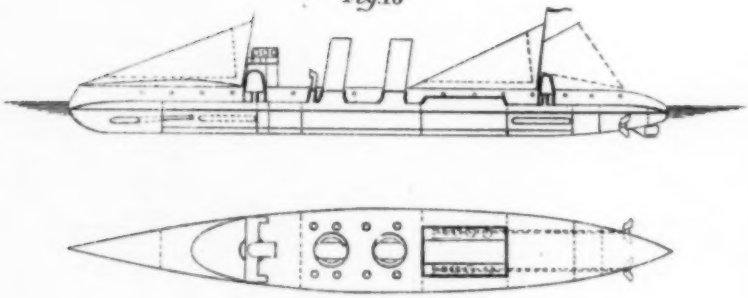
Fig.10 b



AUTOMOBILE DEPT

Under different conditions of Immo

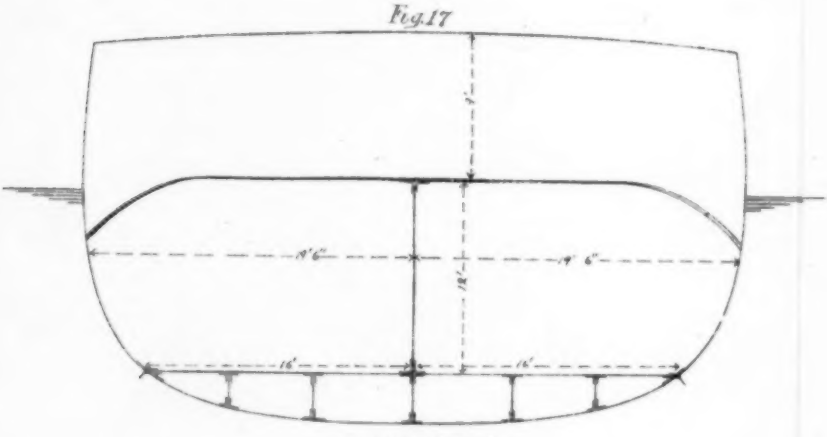
Fig.16



ARMORED TORPEDO CRUISER.

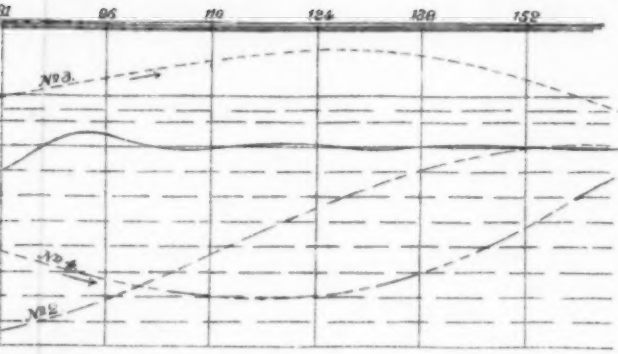
2000 Tons Displ. Sea Speed 24 Knots.

Fig.17



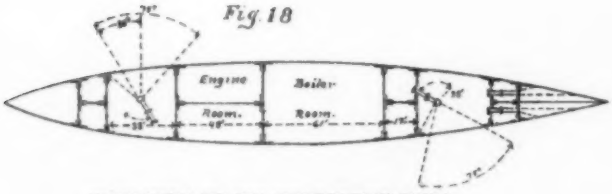
MIDSHIP SECTION.

10 b



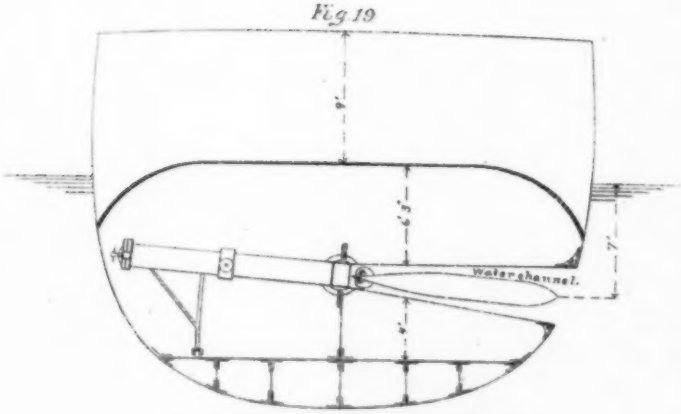
BILE DEPTH CURVES,
s of Immobilizer and Tension Springs.

Fig. 18



PLAN VIEW BELOW PROTECTIVE DECK.
Armored Torpedo Cruiser. 2000 Tons Displt.

Fig. 19



UNDER-WATER BROADSIDE DISCHARGE.
Forward. Frame 76 ft.

FIG. 20.

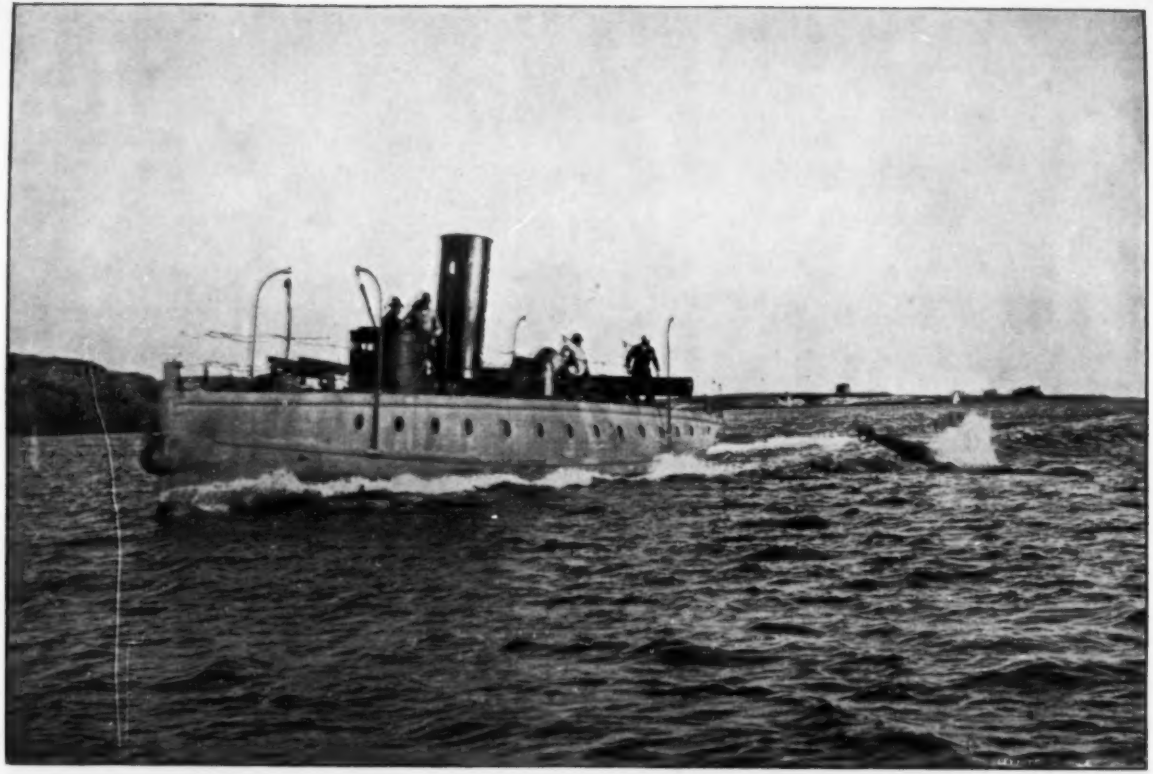


FIG. 21.

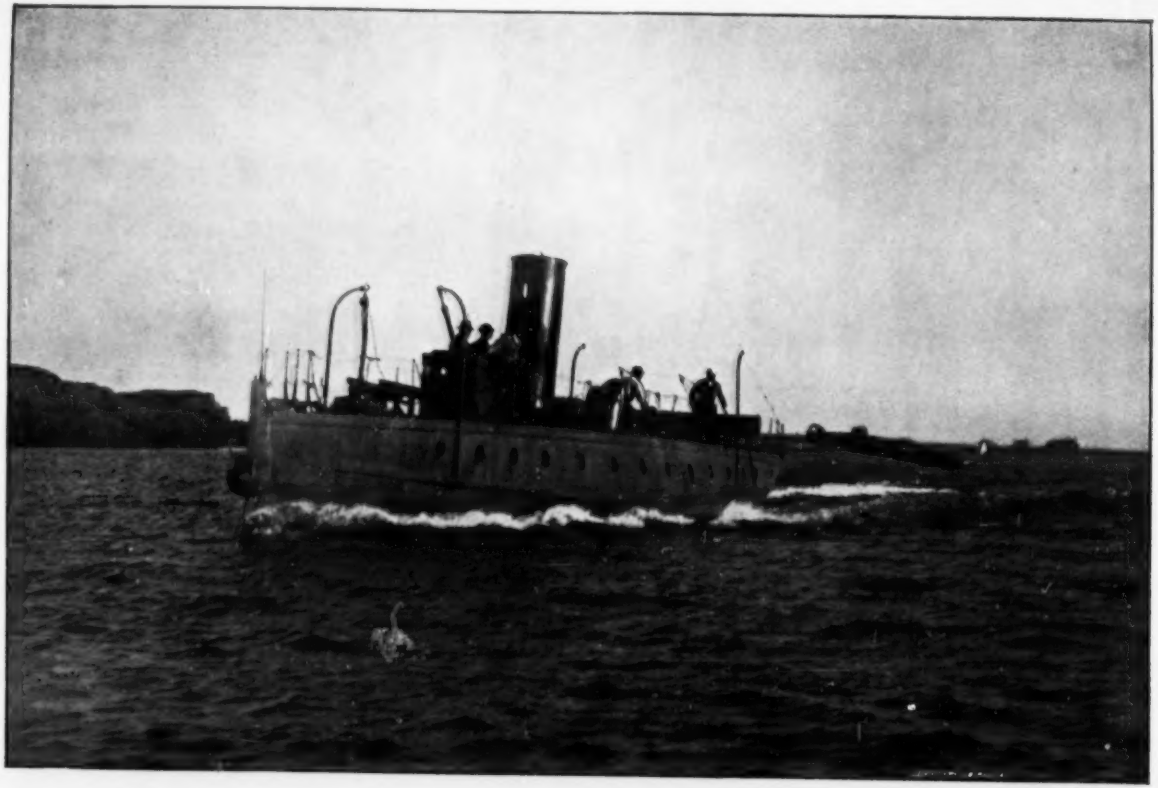


FIG. 22.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE CHEMICAL ANALYSIS OF THE THREE GUNS AT THE U. S. NAVAL ACADEMY, CAPTURED IN COREA BY REAR-ADMIRAL JOHN RODGERS, U. S. N.

By Charles R. Sanger.

This paper was intended to accompany the article by Mr. Thomas Wm. Clarke, entitled: "Notes on the Manufacture of the three Guns at the U. S. Naval Academy, captured in Corea by Rear-Admiral John Rodgers, U. S. N.," and published in these Proceedings, vol. xviii, No. 2. By an unfortunate misunderstanding the analysis was delayed until Mr. Clarke's article was in print, and the two papers could not be published together. As the analysis confirms Mr. Clarke's conclusions, I still think it well to publish it, and Mr. Clarke appends a note with comments on the results.

Mr. Clarke's exhaustive investigation can only be briefly referred to here. The guns bore inscriptions which were translated by the Chinese scholar, Wong-Chin-Foo, of New York. The dates of manufacture of two of the guns were conclusively determined to be 1680 and 1665, respectively, and these two were of a more advanced type than the third, to which Mr. Clarke assigns the date 1313, though this date is more a matter of conjecture than the others. It is very conclusively shown that these guns owed their manufacture in no way to Europeans, but were conceived and executed solely by the Chinese themselves. They point to a great advance in metallurgical skill, and it is of interest to see in what proportion the constituents of the alloy were mixed.

The method of analysis of all the guns was essentially the same, and differed very slightly from that usually employed in the analysis of bronzes. As the object of the investigation was mainly to determine the proportions of the chief constituents of the alloy, the exact determination of the accidental impurities was not carried out,

although the determination was made where it could be conveniently done in the course of analysis.

Portions of the gun were rubbed with sand-paper to remove the weathered surface, and borings were made in several places with a hard steel tool. During the boring the hardness of the alloy was found to vary as the tool advanced, but there was no regularity about this, and it could not be determined that any one of the guns had been exposed to a more scientific process of cooling than the others.

The borings were mixed, washed with ether, dried quickly at a gentle heat, and bottled while still warm. For analysis, they were dissolved in nitric acid, digested at a gentle heat for some time, and evaporated to dryness on the water-bath. The residue was then digested with more nitric acid, evaporated nearly to dryness, and taken up with hot dilute nitric acid. After standing over night, the stannic hydroxide was filtered, washed with dilute nitric acid, and finally with hot water. In some cases the filtration was effected by means of the Gooch crucible; in others, the stannic hydroxide, after incineration of the filter-paper, was moistened with nitric acid, and, after expulsion of the excess of acid, ignited to a constant weight. The stannic oxide thus obtained was free from copper, but no attempt was made to determine any traces of silica.

The filtrate and washings, after separation of the tin, were evaporated with a slight excess of sulphuric acid to dryness, and re-evaporated until the nitric acid was completely expelled. A small amount of water, with a few drops of sulphuric acid, was then added, and, after cooling, an equal bulk of alcohol. After standing over night the precipitated plumbic sulphate was filtered by means of the Gooch crucible, washed with dilute alcohol, and ignited at a low heat. A qualitative test showed the precipitate to be plumbic sulphate.

The filtrate and washings from the plumbic sulphate were evaporated to a bulk of about 50 cc., transferred to a weighed platinum dish, and electrolyzed by a weak current, twelve hours being taken for the precipitation. After decanting the supernatant liquid, the copper film was washed with water, then with strong alcohol, and quickly dried in an air-bath at a low heat.

The liquid from the electrolysis was evaporated to a small bulk with addition of a few drops of nitric acid, and ammonia was added in very slight excess. The precipitated ferric hydroxide (+ aluminic hydroxide, etc., if present) was filtered, washed with hot water, and ignited. The presence of alumina or other oxides in the ferric oxide was not sought for.

To determine the zinc, the filtrate from the iron was evaporated, and boiled with an excess of sodic carbonate until no further evolution of ammonia was perceptible. The precipitated zincic carbonate and silica,* after washing, were ignited and weighed. The residue was digested for some time with moderately strong hydrochloric acid, and the silica remaining was ignited and weighed. From the loss in weight was calculated the amount of zincic oxide present. The filtrate from the digestion with hydrochloric acid showed the presence of zinc by qualitative tests.

The amount of sulphur was determined as follows: After solution of the alloy in nitric acid and separation of the stannic hydroxide, the solution was precipitated with baric chloride, and the precipitated baric sulphate washed and ignited.

Though a complete analysis from one weighed portion was carried out in some cases, yet a separate determination was often made under the same method of separation.

Ordinary qualitative methods failed to show the presence of arsenic and antimony in the guns. These were, however, tested for, both in the stannic oxide and in the first filtrate, by the Berzelius-Marsh method, and, in one case, the presence of antimony was determined in the mirror.

The analytical data are as follows:

GUN OF 1680.

I.	1.3302	gramme	gave	0.1885	gramme	SnO_2,	=11.11	per cent.	of Sn.
II.	1.7996	"	"	0.2574	"	SnO_2,	=11.20	" "	of Sn.
III.	0.4586	"	"	0.4043	"	Cu,	=88.14	" "	of Cu.
IV.	0.4738	"	"	0.4180	"	Cu,	=88.22	" "	of Cu.
III.	0.4586	"	"	0.0038	"	ZnO,	= 0.66	" "	of Zn.
IV.	0.4738	"	"	0.0036	"	ZnO,	= 0.61	" "	of Zn.

Taking the mean of these analyses, we have as the composition of the gun:

Copper	88.18 per cent.
Tin	11.16 " "
Zinc	0.64 " "
	99.98

Traces of lead, arsenic, and iron were found.

* Partly from the sodic carbonate itself, partly from the action of the sodic carbonate on the glass.

Gun of 1665.

I.	0.3044	gramme	gave	0.0338	gramme	SnO_2, =	8.70	per cent.	of Sn.
II.	0.4876	"	"	0.0539	"	SnO_2, =	8.67	" "	of Sn.
III.	0.4486	"	"	0.0491	"	SnO_2, =	8.58	" "	of Sn.
IV.	0.8895	"	"	0.0656	"	$PbSO_4$, =	5.04	" "	of Pb.
II.	0.4876	"	"	0.0365	"	$PbSO_4$, =	5.11	" "	of Pb.
V.	0.4097	"	"	0.3498	"	Cu, =	85.37	" "	of Cu.
II.	0.4876	"	"	0.4157	"	Cu, =	85.25	" "	of Cu.
III.	0.4486	"	"	0.3835	"	Cu, =	85.49	" "	of Cu.
II.	0.4876	"	"	0.0021	"	Fe_2O_3, =	0.30	" "	of Fe.
III.	0.4486	"	"	0.0017	"	Fe_2O_3, =	0.27	" "	of Fe.
II.	0.4876	"	"	0.0037	"	ZnO, =	0.61	" "	of Zn.
III.	0.4486	"	"	0.0039	"	ZnO, =	0.70	" "	of Zn.

The mean of these analyses gives the following composition for the gun:

Copper	85.37	per cent.
Tin	8.65	" "
Lead	5.08	" "
Iron	0.29	" "
Zinc	0.66	" "
	100.05	

Traces of arsenic and antimony were found.

Gun of 1313.

I.	0.9206	gramme	gave	0.1208	gramme	SnO_2, =	10.28	per cent.	of Sn.
II.	0.8577	"	"	0.1133	"	SnO_2, =	10.35	" "	of Sn.
III.	0.6905	"	"	0.6069	"	Cu, =	87.90	" "	of Cu.
IV.	0.4853	"	"	0.4275	"	Cu, =	87.88	" "	of Cu.
III.	0.6905	"	"	0.0094	"	Fe_2O_3, =	0.95	" "	of Fe.
IV.	0.4853	"	"	0.0067	"	Fe_2O_3, =	0.97	" "	of Fe.
III.	0.6905	"	"	0.0042	"	ZnO, =	0.49	" "	of Zn.
IV.	0.4853	"	"	0.0017	"	ZnO, =	0.28	" "	of Zn.
III.	0.6905	"	"	0.0154	"	$BaSO_4$, =	0.31	" "	of S.
IV.	0.4853	"	"	0.0078	"	$BaSO_4$, =	0.16	" "	of S.

The mean of these analyses gives the composition of the gun as:

Copper	87.89	per cent.
Tin	10.32	"
Iron	0.96	"
Zinc	0.39	"
Sulphur	0.24	"
	99.80	

No arsenic nor antimony was found.

The following table gives a comparison of the composition of the three guns:

	Copper.	Tin.	Lead.	Iron.	Zinc.	Sulphur.	Arsenic.	Antimony.	Total.
Gun of 1680,	88.18	11.16	Trace.	Trace.	0.64	Trace.	Trace.	..	99.98
Gun of 1665,	85.37	8.65	5.08	0.29	0.66	Trace.	Trace.	Trace.	100.05
Gun of 1313,	87.89	10.32	..	0.96	0.39	0.24	..	..	99.80

The presence of lead in the gun of 1665 is certainly not accidental.

The greater amount of iron and sulphur in the gun of 1313 would seem to show that the metallurgical processes at that date were not so complete as at the later dates.

The metals used in the guns of 1313 and 1680 probably did not have their source in the same ores.

The guns of 1665 and 1680 were probably cast from metals mined about the same time and smelted in about the same way.

The above work was done at the U. S. Naval Academy, and I have to thank my assistant, Mr. Charles T. Whittier, for most of the determinations.

WASHINGTON UNIVERSITY, ST. LOUIS, *October* 28, 1892.

NOTE BY THOMAS WM. CLARKE.

Ure's dictionary, Hunt's edition of 1867, is a convenient authority upon bronzes. Of course it does not treat of the various peculiar bronzes of late years, such as the Amsterdam ferro-bronze, or the Ajax metal, or the Uchatius metal, aluminium bronzes, or phosphor-bronzes of our present advanced metallurgy. But so far as the old alloys of copper with zinc, tin, and lead are concerned, it is probably as nearly complete as any single work.

From this it appears that actual cannon of the last part of the last century analyzed: Copper, 89.360; tin, 10.040; lead, 0.102; silver, zinc, iron and copper, 0.498 (vol. i, p. 492). In other words, the formula was in substance 9 of copper to 1 of tin, with a little lead for fluidity. A Roman sword analyzed: 85.70 of copper and 10.02 of tin, with a probable formula of 8 to 1. The curious metallurgy of the Assyrian bronze shell which Layard found in the palace of Sennacherib, and which has since been called the leg of the throne of Sennacherib, analyzed: copper, 88.37; tin, 11.33, with a probable formula of 8 to 1, if we do not count loss by oxidation, or 7½ to 1 if we allow for that. Papacino d'Antoni, in studying the qualities

of bronze for a cannon a century ago, fixed the proportions of 100 of copper to 12 or 14 of tin, or somewhere between 7 of copper to 1 of tin and about 8 of copper to 1 of tin, while Lamartillière determined in 1787 that from 8 to 11 per cent. of tin should be employed in 100 of bronze, or, in other words, from 8 to 10 parts of copper to 1 of tin.

Analysis of ancient coins shows that the proportions of copper to tin varied from that of 5 to 1 to that of 16 to 1, with additional elements which in some instances were two or three times the amount of tin or a third the amount of copper, and in others as little as a mere trace.

The best steam metal of to-day for high-class work, I have found by examination of foremen of bronze foundries, is made of nine or ten parts of Lake copper and one part of East India tin (Banca or Straits), with occasionally, perhaps usually, one per cent. of lead or less added to lower the melting-point and save the tin from oxidation.

The bronze weapons of Troy found by Schliemann vary in composition, from the lower stratum to the upper, from the ratio of twenty of copper to one of tin to the ratio of ten of copper to one of tin.

We are then authorized to believe that from about B. C. 1000 till now, the ideal bronze for tensile strength and hardness has been about 9 copper to 1 tin.

This is the weapon-bronze of Troy, of Greece, of Rome, presumably of Assyria, and of the Chinese gun of 1313.

	Copper, Iron and Sulphur.	Tin.	Ratio.
Gun of 1313,	89.01	10.32	9 : 1

The iron and sulphur were counted above with the copper as undoubtedly derived from the copper ore. The ratio of the two metals was within the best European limits of 1770.

The gun of 1680 has the lower formula of 8 copper to 1 tin, which the European experiments of 1787 determined was the extreme allowable proportion of tin for the best gun-metal.

The composition of the gun of 1665 curiously checks the history of the times. Tin is a most sensitive index of the condition of international commerce. Saxony, Bohemia, and Spain furnish small supplies; Cornwall puts out a good deal more than half the world's supply, and the Malay peninsula and its south-trending islands

nearly all the rest. The world probably requires to-day less than fifty thousand tons a year. In 1665 it did not probably consume three thousand tons, and half of that was Cornish. The Chinese are said to have some tin-washings, and to smelt a small indigenous supply, and China must always have relied almost wholly on Straits tin brought in by sea.

When the Chengs ruled the sea from their Formosa stronghold, they pillaged the flotilla of China down to the smacks and market boats of its shore fishery, and ravaged and plundered its coasts for three marine leagues inland. Only the vassal kings of Qwang Tong and Fokien maintained occasional foreign relations by a surreptitious, almost a treasonable, tribute to the toll-taking corsairs of the Formosan prince. In this political condition a scarcity of tin must have been an early and notable result. Old metal would be sought on every hand, and adulteration practised in its largest limit.

Those familiar with the early Chinese curios brought to America will recall some carved or lacquered tea chests of a capacity of forty pounds or less, with locks and keys, each of which boxes contained an interior metallic shell not made of sheet lead and paper like the ordinary "tea-lead," but of considerable thickness, often ornamented with decorative patterns on top. These inner coffers had a central neck, a jar-cover which fitted over it, and an inside cover which fitted into it, and were said to be of block tin. They really carried a notable per cent. of lead. The use of such an old metal would account for perhaps a quarter of the lead found, but not for more. The percentage of lead in the gun of 1665 must have been caused by a positive dearth of tin and an attempt to find a substitute. This proof that foreign commerce was cut off shows a curious mechanical result from a political situation.

The form of these cannon, with their hollow cascables and their breech-block recess evidently produced by coring or by employing a three-part mold, shows high technical skill in the artizans. This is also shown by the finish of the recessed cartridge chamber in the ear of the barrel. Not very conclusive trials of hardness and examination of textures of the metal lead me to the opinion that the barrel was cored from end to end, and that the guns were cast upright, muzzle down. They seemed to be a little harder and denser at the muzzles than at the cascables, and not to vary on transverse planes.

From the fact that each gun is of special design, and differs from the other in ornamental detail and in the emplacement of the trunnions

with regard to the bands, one is warranted in saying that these guns were severally modeled in loam by the modeler, as bells and hollow-ware are molded, and, from the fact that Chinese art furnishes so few replicas, one is perhaps justified in saying that the use of patterns was unknown to it until Father Verbeist introduced them about 1678. His guns were certainly cast from patterns, and perhaps it was this art that he taught.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

OCTOBER, 1892.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XXIV.

On account of its value, we reproduce at length, from the J. Soc. Chem. Ind. **11**, *203–212*, 1892, Oscar Guttmann's paper on "The Dangers in the Manufacture of Explosives." With a few exceptions, the dangers in connection with explosives may be summed up in the terrible word "explosion." Those who have witnessed one are never likely to forget the impression. A sharp report, huge red flames shooting towards the sky, followed by indistinguishable dark masses, then a dull shower of falling pieces, followed by a dead silence. Where a second ago a neat-looking building stood, and busy hands were working, there is now a deep hole in the ground, and all around at great distances lie scattered the fragments of house, machinery, and workers. It is difficult even to identify these last. Their clothes, if not of wool, are burnt away, their features are no longer recognizable, and sometimes a boot, or a limb, or a mark on the body is the only clue. The cause of the explosion can rarely be traced with certainty. Whoever has read the reports of Her Majesty's Inspectors of Explosives will have nearly invariably found more than one possible cause given, but they will at the same time have been astonished to find a power of generalization displayed which has never yet failed to teach some sound moral for the benefit

* As it is proposed to continue these Notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address, Columbian University, Washington, D. C.*

of those concerned. Unfortunately such reports are published only in Great Britain, and the few short notices which reach other countries are quite insufficient to give manufacturers adequate information to enable them to provide effectively for the protection of their work-people and their property. A feeling that it is the duty of each one to relate his experiences has led the author to give an outline of the sources of danger involved in the manufacture and use of explosives.

It is generally agreed that an explosion must first be defined as the sudden decomposition of a mechanical or chemical mixture into its components, whereby in a short space of time a great pressure is developed. Such an explosion may be started by different means, and they are by no means the same in each case. Sometimes ignition will start the decomposition, sometimes a shock, friction, an electric spark, vibration, sudden heating, etc.; but as a rule it is necessary, as Sir Frederick Abel pointed out first, that a certain amount of vibration, and vibration of a distinct nature, be generated as a result of either of the above causes, in order to produce explosion.

The explosion is quicker, the larger the number of vibrations in unit time. The stronger the effect, the higher the heat produced and the larger the quantity of gases developed, as their expansion increases in proportion to their temperature. An explosion has the maximum effect when the vibrations, the heat, and the quantity of gas reach their maximum at the same time.

Here may be mentioned some of the more conspicuous examples of explosions. Chloride of nitrogen explodes when thrown into boiling water. If a minute piece of paper, smeared with iodide of nitrogen, the temperature of explosion of which is 212° F., be allowed to fall from a height of about 3 feet, it will explode on touching the ground. If such a piece of paper is put on a base-viol and the E chord is struck, it is not influenced, but if the G chord be struck, which gives more than 60 vibrations in the second, it explodes. If a gunpowder mixture be ignited in a tamped bore-hole it burns away by layers until the pressure of gas and heat cause explosion. If dynamite be ignited in this way it will simply burn without detonation. If laid on an anvil and struck sharply at an angle ("glancing blow"), all explosives in practical use will detonate. Dynamite explodes between steel and steel when 5.63 foot-pounds of work are done upon it (0.78 kilogramme-metres), gunpowder at 56 foot-pounds (7.57 kilogramme-metres); but whereas the explosion travels through the

whole of the gunpowder, dynamite, as a rule, only detonates in the part struck by the blow. If a dynamite cartridge be exploded on the top of a gun-cotton charge the latter will only burn away, but if the places are reversed the gun-cotton is sure to detonate the dynamite. Each explosive has a certain temperature beyond which it cannot be heated suddenly without detonation. This temperature is, for example, 212° F. for iodide of nitrogen, from 356° to 363° for nitro-compounds, and 518° to 608° for gunpowder.

It is therefore obvious that an explosion is not solely due to the explosive being heated to a certain temperature. In fact, the shock or friction may be quite insufficient to raise the temperature to any appreciable extent, even if the shock be concentrated on å single point, as in the case of a "glancing blow."

On the other hand, anything which is likely to produce vibrations of a sufficient amplitude and frequency in the explosive should be carefully guarded against. Thus, for instance, it is well known that a tuning-fork will give a greater number of vibrations if struck against an object of steel than against brass, stone or wood; and the same applies to any shock against an explosive lying between different bodies. Steel against steel is the most dangerous, wood against wood the most harmless. Yet it has been proved by Dr. Dupré that a glancing blow with a broomstick against a wooden floor will cause the explosion of most explosives. Of course it depends greatly in what condition the explosive itself is. A blow given to a full cartridge of blasting gelatin may be quite harmless; but if sufficient force be used to flatten the cartridge and expose the last thin layer to a sufficient amount of shock, then an explosion of the whole cartridge may follow. There is also a great difference between the explosive being warm or cold. When warm, explosives are as a rule more sensitive, both to decomposition and to shock or friction.

The causes of explosions may be placed under two headings, mechanical and chemical. The mechanical causes are mainly due to shock, friction, or ignition of some sort. The chemical causes vary with the nature of the explosive. Mechanical mixtures, such as gunpowder, roburite, etc., are, under ordinary circumstances, exempt from dangerous chemical changes; but chemical compounds have always a certain amount of instability, which can only be avoided by careful manufacture. Of course there are also mechanical mixtures which are liable to decomposition, and I need only mention the chlorate mixtures, which, especially in the case of fireworks, have led to many accidents.

In the following account each explosive will be dealt with separately, and the dangers attached to it at each stage of its manufacture pointed out. Of course only those explosives which are actually manufactured and in use will be spoken of, it being left to you to draw your own conclusions, by the similarity of cases, when other explosives come under your notice.

Gunpowder.—First by seniority and by the number of factories making it come gunpowder and its imitations. In this case, as in that of every other explosive, a very important condition is that the materials employed should be of the greatest possible purity, both chemically and mechanically.

In the nitrate (saltpetre, sodium nitrate, etc.), chlorine is the principal impurity. Although in the case of true gunpowder no saltpetre is now used which contains more than one ten-thousandth part of chlorine, yet with gunpowder imitations, especially where sodium nitrate is used, this is not always the case. An assistant of mine once made some powder mixture, extracted the nitrate, which contained a large amount of chlorine, from it, evaporated the solution in a porcelain dish to dryness and complete fusion. He then allowed it to cool, and after some time began to move the cake with a glass rod, when suddenly the whole flashed up. In this case it is evident that some nitrogen chloride had been formed, the liability of which to explosion by the slightest vibration is so well known.

Care has also to be taken that no saltpetre or powder comes in contact with a soldered joint. Weber found in a particular case that nitrate of tin was formed, of which there is an explosive variety; this has caused frequent accidents.

The charcoal presents no other danger than that of spontaneous combustion. It is a good practice to have the charcoal first ground in separate machines. Spontaneous combustion is due to the capacity charcoal has of absorbing and condensing the air, producing thereby heat. This may sometimes take place suddenly, as, for instance, when a piece of charcoal is broken, and the interior, which has preserved its absorbing power, is brought into contact with moist air.

The sulphur is now generally ground before mixing it with the other ingredients. Although by quick grinding a large amount of heat may be produced, this is scarcely ever sufficient to fire the sulphur. But sulphur mills very often take fire, and this is chiefly due to the well-known electrical qualities of sulphur, which are made evident by the friction and heat in grinding. A friend of the author

connected his sulphur mills with the earth by means of copper wires so as to carry away the electric charge as it was produced; since this time he has never had a sulphur mill fire.

If a ventilator is used to carry away the sulphur dust, its exhaust-pipe should go into a collecting chamber, as sulphur dust is dangerous.

In this country stamp mills are no longer used for the incorporation of gunpowder, but elsewhere they still exist. They have generally wooden beds and brass stamps, and but for the presence of grit, or some broken metal parts, they are safe enough, provided the powder is frequently "liquored." Still, most of the accidents occur with them, as these two conditions of safety are often accidentally absent, and the great amount of dust, thrown in the air by the violent blows of the stamps, takes fire easily by a spark, or by the friction of a stamp-pole.

Mixing drums were formerly largely used, and seem to be coming into use again in this country, for certain kinds of powders. As they are made of "sole" leather or wood with brass or wood balls revolving in them, there should be no other danger in them than comes from overheating due to the quick movement. There is still another source of danger which will be dealt with presently.

The machines chiefly used for the intimate mixture of the gunpowder ingredients are the "incorporating mills," having generally pans and runners of cast-iron. Sometimes the beds are made of wooden blocks on edge. Incorporating mills are known to explode from time to time, and formerly the well-worn excuse of a match or a nail having got into the mill used to be a readily accepted explanation of the accident. Such an occurrence of course is possible, but must be very rare indeed. The chief cause is faulty construction of the mills. The runners weigh from four to five tons, and if the cake in the course of milling becomes dry and hard, the runner may lift in passing over a thicker piece and then fall down on to a thin one. Good incorporating mills are now made in such a way that the runners always remain one-sixteenth inch off the bed, so that the iron can never come in contact with iron. Another cause, which applies to mixing drums and nearly all other powder machinery, is electricity accumulated by the friction against the sulphur. Some years ago the author devised the "earthing" of incorporating mills, and he believes that the number of accidents has considerably diminished where his suggestion has been adopted. It is known that many of

the explosions in incorporating mills happen where they are suddenly stopped or started after a stoppage, whereby a great amount of vibration is of necessity set up in a single moment. Many accidents happen also in removing the cake from the bed, or when repairs are being made. It is essential and rightfully enforced by Her Majesty's Inspectors that the cake should only be taken away when damp, and that no repair should be done without having previously thoroughly washed and cleaned the whole building. The use of brass tools in such a case is only a diminution of the risk, and is not by any means a safeguard against accident, and even wooden implements should only be used after the charge is well moistened. To prevent communication between one mill and another, which very often are driven in pairs from one water-wheel or line of shafting, the drenching apparatus has proved to be very effective. Briefly, this is a water-tank placed on the top of a mill, and held in equilibrium by a "shutter," a flat lever board, which, when raised in the least degree, upsets the tank. All the shutters are connected by a shaft, so that when an explosion in one mill takes place, all the other charges are immediately drowned.

When an incorporating mill explodes, the building only is, as a rule, damaged, and that not always much. A friend of the author's has adopted the excellent system of constructing the roof of the building with a very light framing, and securing the whole roof by two loose wooden pins only. If an explosion occurs the roof is simply lifted, giving enough opening to the gases to escape before sufficient pressure to materially damage the building can be set up.

The mill cake is next powdered in a "breaking-down machine," which is essentially a roller mill with one pair of grooved and one pair of plain rollers. This machine requires no more attention than any other powder machinery, except that it should be so made that the pressures on the rollers cannot exceed a certain limit. This is generally done.

Next comes the pressing, which is now generally done by hydraulic machines, roller presses being very rarely used. Formerly this pressing was done by placing in a square wooden box with hinged sides a layer of powder meal and a brass plate alternately, and then pressing a block of hard wood into the box. This caused the powder to adhere so strongly to the sides of the box that it required a good deal of force to open it, and sometimes occasioned accidents. Nowadays the damp powder meal is, as a rule, laid on an ebonite

plate, another placed on the top of it, and so on, layers of powder and ebonite occurring alternately until the required height is reached. This way of pressing is comparatively safe, provided great care is taken to keep the presses clean, and the hydraulic ram is not allowed to fall down too quickly. But there is again the danger of electricity, which in this case especially must not be underrated. The charge of a cake press with ebonite plates can practically be considered as an electric pile, and a large amount of friction or electric influence from outside may cause a sufficient electric charge to give off sparks. Several cases have been known, and the following instance occurred at a large Continental factory. The workman, having just finished charging, opened the valve for the hydraulic pressure, when he became aware of an approaching thunderstorm. According to his instructions he left the building and returned after the thunderstorm had passed away, but when he began to discharge the press it exploded. The man died, but stated before his death that in undoing the cakes a spark four inches in length came on his finger.

It is therefore advisable to take great precautions in using ebonite. It is a very convenient material, being very tough, of smooth surface, hard and not subject to much wear and yet sufficiently elastic; it is, therefore, largely used for plates in cake presses, for the lining of hoppers in granulating and sifting machines, etc., but care must be taken that no electricity can accumulate even under unfavorable circumstances.

The reduction of the powder cake into grains is done by a machine similar to that used for breaking down the mill cake; the grains formed are continuously classified as they fall from the rollers by sieves placed underneath. There is a large amount of dust produced in this operation, and the author has not yet seen a single graining machine where the escape of dust into the room has been perfectly avoided, but he has seen many houses where the air looked worse than a London fog, and where with open doors you could see the cloud of powder dust coming out for more than three yards. As a matter of course, there is shafting in the house, the graining machines themselves contain a number of cog-wheels, bearings, etc., and sometimes the shafting itself is driven by a cog-wheel from another line of shafting. These cause a good deal of noise, which, together with the darkness in the room, produces a very uncomfortable feeling.

In many factories the graining is still done by the Lefebvre system, which consists of one or more sieves oscillating either longitudinally or in a circle, in which a weighted boxwood disk, hewn like a millstone, is moved to and fro, thereby breaking the cake. This way of graining produces, of course, still more dust.

In some places a ventilator may be found which draws out the powder dust though an opening in the building, and deposits it on sheets of cloth, but it is never efficient enough to clear the atmosphere of the room. It is the author's belief that a suitable casing round the graining machine, and a hood on the top in connection with a good exhaust, leading in a depositing chamber, would answer the purpose much better. No cog-wheels should be allowed on the shafting inside the building. They do not always gear perfectly, and wear out in time, which causes dangerous knocks, and it would perhaps be advisable to put the shafting altogether outside the house, unless it runs at a low speed. The bearings of the graining machine should be provided with constant lubricators, such as Stauffer's solid grease cups, which prevent the inconvenience of the oil dripping about, and keep the bearings constantly greased.

During the glazing, rounding, and sieving, the powder is subjected to a constant friction of its particles against each other; and during the glazing especially, where there is still a large amount of moisture, a good deal of heat is developed. The plugs in the glazing barrels must be opened at regular intervals to allow the escape of steam formed, and care should be taken with all these revolving machines to carry away any electric charge that has accumulated, which is easily done.

The drying of the powder is no longer done in the open air, however convenient this may have been. There was always the risk of grit flying into the powder, and of concentration of the sun's rays, if exposed to it. Artificial heat is now generally resorted to, and in very few cases only are the fumes of a stove carried in pipes to the drying house. Steam, hot or warm water, are nearly always adopted now. The introduction of steam or hot water pipes into the building itself is objectionable, as a certain amount of dust, which is always produced in charging and emptying the trays, accumulates on the hot pipes. Warm water pipes increase the time of drying a little, but are not open to this objection. The best way is certainly to have a steam or hot water stove outside the building, and to drive, by means of a fan, a current of air over the stove into the drying cham-

ber. This allows an even temperature to be kept, and removes all danger, provided that the air inlet be so arranged that the current of hot air cannot pass directly over a layer of powder.

Sometimes the press cake is cut in large cubes for the so-called pebble or cube powder. No special allusion may be made to these machines, whatever may be their construction, as the exclusion of hard blows, the attention to knives, bearings, etc., is the same as with all other powder machinery.

The process which requires the most attention, and which is not always in expert hands, is that of compressing the powder into prisms, cylinders, pellets, etc. There are two classes of presses in use, lever and hydraulic presses. With a lever press generally the powder is charged into a mold, closed at the bottom by a piston, and another piston is brought down on the top by a lever actuated by an eccentric. Of course there is a great variety of such presses. Some have a "block" with many holes, into the bottom of which comes a disk, then the powder charge, then a piston, and the whole goes under a press. In some presses the mold revolves on a table, and its holes are alternately opposite a plain part and a perforated part of the table, and, at the same time, subject to a piston compressing the charge, and, on another part, to a longer piston forcing the compressed cartridge through the hole in the table, whence it falls out in a receptacle. Sometimes a hopper slides over the mold, fills it, glides away, and the charge is forced out. Sometimes the mold is fixed, sometimes it is balanced during the compression, whilst a piston enters the mold from the top and from the bottom.

These latter presses are, perhaps, the best in the way of lever presses, provided the mold be guided vertically, and one of the two pistons has a safety arrangement, to prevent excess of pressure. Lever presses, where more than one cartridge is pressed at a time, are objectionable, as they seldom have a safety arrangement, and to make such a one effective would cost as much as a suitable hydraulic press.

It is well known to everybody who has had to do with the compression of pulverulent substances, that it is most difficult to have a number of molds filled with exactly the same quantity in each. Even little hoppers, which open at a certain weight, will fail to give more than a rough equality. Also the state of the atmosphere and the shape and diameter of the mold make a difference, as does also the size of the grains in the case of gunpowder.

Although gunpowder can bear a great pressure without injury, yet it is not advisable to do much in this direction, as it is very easy to get local overheating by the presence of a foreign particle or a hard grain. Also the more powder is compressed, the more it will adhere to the mold, and in pushing out the cartridge a greater pressure will be required. It is the friction thus caused which produces the greatest heat, and where the most danger exists. When, therefore, a number of molds are not equally charged, and they are all compressed by pistons fixed on a common head, the cartridge which contains most of the powder may, at a certain stage, receive all the pressure intended for the lot, and will, in any case, get more than its share. Hence the necessity of an arrangement to prevent an excess of pressure. This can be done by weighted levers on the bottom pistons, or, much better and simpler still, by keeping each mold independent and movable.

The same applies to hydraulic presses. Most of them have one ram only, so that the cartridge, which may vary from 1½ to 3 inches in height, is far more compressed on the bottom than on the top. Those with one ram on top and bottom make a better compression, and want less pressure on either side, but they are costly and cumbersome. In neither of them, as a rule, is any arrangement to prevent an excess of pressure provided, and the best means of doing this is the movable mold.

Presses for prismatic powder, where needles of phosphor-bronze enter the molds, require careful inspection, as the slightest bend of a needle can cause breakage.

Another method of powder manufacture may be briefly mentioned, which was long ago known to the Tartars, and some nine years ago practised in this country. This method is to dissolve the saltpetre in hot water, add the other ingredients, and boil down the whole with constant stirring during the evaporation. The English system of inspection would have soon put a stop to the way in which this was done for some time on the Continent, where this process was carried out in a kind of washing copper with a coal fire underneath, and where the contents of the copper sometimes went off through part of the powder being caked at the bottom and excessively heated.

The manufacture of cocoa-powder does not differ from that of ordinary gunpowder except in the preparation of the charcoal, which is no more dangerous than the work of a rag-boiler.

In connection with gunpowder may be mentioned also the manu-

facture of safety fuses. This presents no particular danger, except that in spinning the first layers of the fuse, where a fine stream of powder falls in as the fuse is formed, the excess of powder falls on the floor, covering a large area, requiring precautions to be taken against friction or the fall of the weight which keeps the fuse stretched.

Nitro-compounds.—The next group to be dealt with are the so-called nitro-compound or chemical explosives. These are produced on a very large scale, and gain daily in importance; but their manufacture involves generally a great amount of machinery and apparatus, and the knowledge of all the accompanying circumstances is still far from being perfect, besides being sometimes of a very complicated chemical character.

Nitro-compounds are liable to explode at a lower temperature, are more sensitive to concussion and friction than gunpowder, and in addition, as products of chemical action, are liable, under unfavorable circumstances, to undergo chemical changes which may render them unstable.

A nitro-compound is generally formed by the action of nitric acid on a hydrocarbon, sulphuric acid being added in order to take up the water formed during the process and to keep the nitric acid as far as possible at its original strength, so as to avoid the formation of lower nitro-compounds, which would either reduce the force of the explosive, or even render it unstable.

Comparatively the least dangerous to manufacture are gun-cotton and collodion cotton. With the exception of the nitration and the compression into cartridges, the whole process is worked with a large excess of water, and although it is quite conceivable that a particle of gun-cotton surrounded by water may explode when struck by a heavy weight, yet such a case is hardly likely ever to occur.

The cotton has to be very carefully purified from resinous matter and soluble substances, as they would form unstable by-products if allowed to remain. This is usually effected by boiling the cotton in a solution of soda. The nitration is done in England by dipping the cotton into the mixture of nitric and sulphuric acids, which are contained in a cast-iron vessel, squeezing it roughly out on a grid, and then letting the nitration complete in earthenware pots, which stand in running water. On the Continent they employ nitrating machines, consisting of a cast-iron vessel with a lid screwed on, having a false bottom which can be moved by means of a screw passing through

the lid. The cotton remains in the machine during two hours, and then the false bottom is lifted towards the lid, thus squeezing the cotton out. In another factory suction is applied underneath the false bottom to drain the cotton.

The nitrated cotton is further deprived of the bulk of its acid by treatment in a centrifugal machine, whence it is passed as quickly as possible into a washing machine.

Care has to be taken that the acid cotton remains constantly under the acid or the water, or at least well covered, else, as it absorbs moisture rapidly, it decomposes, and once a decomposition is started it is almost impossible to stop it. This decomposition is attended by large volumes of red fumes, and sufficient means of ventilation and escape for such have to be provided from the outset in case they are formed. The warmer the mixture, and the less liquid acid it contains, of course the more liable it is to decomposition, hence it is on warm and moist days centrifugal machines are most liable to fire; this seldom happens in the winter, unless some water, oil, or other foreign material falls into it.

Once it is immersed in the washing machine, whose water has to be constantly changed, the gun-cotton is no longer subject to sudden decompositions during the subsequent processes of manufacture, but the acid still remaining in it has to be eliminated with the greatest care, or else a gradual decomposition will take place. I will not detail this manufacture, as it is well known; suffice it to say that gun-cotton which stands the English Government's heat tests is quite safe under all ordinary circumstances.

The compression of gun-cotton into cartridges requires far more care than that of gunpowder, as this is done in a warm state, and gun-cotton, even when cold, is more sensitive than gunpowder. When coming out of the centrifugal machines the gun-cotton should always pass through a sieve, in order to detect nails or matches which may by chance have got into it. What has been said as to gunpowder presses applies still more to those for gun-cotton, although the latter are always hydraulic presses. Generally the pistons fit the mold perfectly, that is to say, they make aspiration like the piston of a pump. But there is no metal as yet known which for any length of time will stand the constant friction of compression, and after some time the mold will be wider in that part where the greatest compression takes place. The best metal for this purpose has proved to be a special steel made by Krupp, but this also is only

relatively better; for pistons I prefer hard cast-iron. If the position of the molds and the pistons is not exactly the same in all cases, what the Germans call "Ecken" (English, "binding") will take place, viz., the mold will stand obliquely to the piston, and a dangerous friction will result.

For certain purposes, such as torpedoes, engineers' cartridges, etc., the gun-cotton has to be turned in a lathe, or drilled or planed. This should always be done under a constant stream of water, to keep the tool cool, as well as the gun-cotton in contact with it.

Of course, it is necessary to protect the man working the hydraulic valves during compression. At Waltham Abbey they have a curtain made of ships' hawsers which is at the same time elastic and resistant. The author has found from experience that a partition wall 12 inches thick, made of 2-inch planks, and filled with ground cinders, gives very effective protection. There are scarcely ever more than 5 lb. of gun-cotton under pressure at the same time, and in the case of an explosion the parts projected embed themselves in the timbers. The roof or one side of the building should be made of glass, so as to give the explosion a direction, and as a matter of fact it will not injure the walls of the building, even if they are only one brick thick.

The drying of gun-cotton is no less attended with risks, if it is done by improperly constructed arrangements. It is generally accepted that the drying should not take place at a higher temperature than 104° F. To secure this an electric alarm thermometer should be provided. If a current of hot air passes over a layer of gun-cotton, the cotton becomes electrified, and most, if not all, the fires in gun-cotton drying houses are due, in the author's opinion, to a neglect to carry away this electricity.

I am indebted to Mr. Walter F. Reid, F. C. S., for much information in this respect. He was the first, so far as the author knows, to make metal frames, carriers, and sieves, upon which is secured the cloth holding the gun-cotton, and to earth them.

In drying-houses there is a large amount of gun-cotton dust produced, which deposits on walls, floors—in fact everywhere. This dust, being warm, is very sensitive to friction; in fact, Colonel Cundill once told me that even the hard friction with a felt shoe had been known to fire it. The workers in these rooms should therefore always wear felt shoes or go barefooted, avoid all unnecessary friction, and frequently wash the floors and walls. The floor should be covered either with india-rubber or linoleum.

On no account should an exposed metal pipe for the conveyance of heat be allowed in the drying room. Although the heat may not exceed 104°, and the radiation of the pipe may be sufficient, yet there might be a more sheltered place, such as a bend, a corner near a wall, etc., where the quantity of heat is accumulated, and a far higher temperature reached than that of the air entering, and it is just such places that will be filled with cotton dust, which itself will serve as an accumulator of heat. An accidental blow on the metal pipe may also happen, so that it is best to exclude them altogether from the room.

The above remarks about gun-cotton apply to mixtures of nitrate and gun-cotton, such as tonite, potenite, etc.

The manufacture of nitroglycerin and dynamite is by outsiders generally considered as an extremely dangerous one, and it certainly is in the hands of untrained and inexperienced people; but if conducted by experts it is far less risky than the manufacture of gunpowder. Still, as it is essentially a chemical operation, its safety will always depend upon the amount of care bestowed on it by the workpeople; it requires a great deal of supervision to be always on the watch for neglect of duty.

The sources of danger rising from the raw materials will first be considered. The nitric acid used should be reasonably free from peroxide. Opinions differ as to what is a reasonable amount, and no doubt the heat developed during the process of nitration is increased by the presence of this, a large amount of hyponitric acid; and, if sufficient care be not taken, may cause decomposition and explosion. Some say it should not contain more than 1 per cent.; but some of the most perfectly conducted factories use it with even more than 4 per cent. The author's experience has been that nitric peroxide undoubtedly produces more heat by its great oxidizing power, but as the temperature of the mixture is always kept under about 77° F., it means that the nitration will last longer, because the workman must allow less glycerin to run in, and consequently he is expected to be still more attentive. Hyponitric acid also reduces the yield of nitroglycerin considerably. As a rule, those factories which buy their nitric acid insist upon having as little hyponitric acid as possible, sometimes below half a per cent., and those which make their own acid are not particular about 1 per cent. more or less. If the process of nitric acid making is conducted in such a way that a minimum of hyponitric acid be present, it will be difficult to have more than 93 per cent. pure monohydrate, and a large quantity of weak acid will

result. If highly concentrated acid only is made, containing 95 to 96 per cent. pure monohydrate, then more heat has to be applied, which will always decompose some nitric acid into hyponitric acid. Of course, a high percentage of monohydrate and no weak acid are most to be desired, because the first gives infinitely better results, whilst the latter is of little value, and if, therefore, the hyponitric acid should be eliminated, then a costly and tedious process of bleaching is necessary. This is the reason why a dynamite factory which makes its own nitric acid has never been known to have less than 2 per cent. of hyponitric acid as an average, but some even as much as 7 per cent. A new process which the author has recently invented gives invariably less than 1 per cent. of hyponitric acid with from 95 to 96 per cent. pure monohydrate, and this is now being rapidly introduced into many factories. This process can even be worked in such a way that the acid will not contain more than one-tenth of a per cent. of hyponitric acid, and acid with even as much as 99.40 per cent. pure monohydrate has been made by this process. This is the strongest acid ever manufactured on a large scale, but there is a great amount of the possible yield lost. It may therefore be said that unless the nitric acid is after its manufacture submitted to a long and expensive bleaching, the best which can be made on a commercial scale will always contain about 1 per cent. of hyponitric acid. As it is scarcely to be expected that everybody can have the very best acid, the limit of hyponitric acid may be set at 2 per cent., which does not increase materially the danger of too much heat being developed. Beyond this limit the heat of the mixture may rapidly increase, and the workman has to be constantly on the alert to shut off the inflow of glycerin, or to apply more vigorous cooling and stirring. As it is desirable that every process should depend as little as possible on the attention of the workman for avoiding accidents, an excess of hyponitric acid should not be allowed.

Sulphuric acid and glycerin are nowadays made very pure. Arsenic may be in both, especially in the sulphuric acid, but it should never be allowed to exceed one-tenth per cent. on account of the well-known strong oxidizing action of arsenious acid.

Glycerin is a very intricate substance, so far as its use for making nitroglycerin is concerned. Of course, a large amount of organic matter, such as cellular substances from the tissue or fatty acids, are both objectionable, as they form unstable compounds during nitration. The presence of chlorine has also to be avoided, because it will

ultimately form hyponitric acid. But even if the glycerin is nearly perfectly pure, and contains nothing whatever but about 0.15 per cent. of total residue, organic and inorganic, it will sometimes happen that the nitroglycerin made is full of a bulky, flocculent matter, which prevents its separation from the acids for a very long time. This only happens with glycerin of a special manufacture, and up to now even so high an authority as Mr. Otto Hehner has been unable to find out to what component or impurity this is due.

The operations of nitrating and separating the nitroglycerin do not require more attention than that the temperature should not even at the finish exceed 86°. I do not refer by this to the Boutmy-Faucher process, which in itself had a special source of danger, inasmuch as in it the sulphuric acid was first allowed to act upon the glycerin, which caused the organic impurities to become charred and to form minutely suspended carbon particles. This prevented the nitric acid, at its highest concentration, penetrating every particle of glycerin, and sometimes prolonged the separation for days. It will be explained later on why this must have been dangerous, or is still so, as the process is still said to be used on a small scale at the French Government factory at Vonges.

It is in the apparatus used for nitration and separation that the chief danger lies, on account of their construction. The nitrating apparatus is now generally a large lead tank, with a number of cooling worms, through which cold water runs. The tanks are closed at the top, with suitable openings for the admission of glycerin and compressed air, for the escape of the fumes, and for the constant control of the temperature, also for discharging the tank either into the separating apparatus or into a drowning tank. All these arrangements of course complicate the nitrating apparatus, and require constant attention. A detailed description of the different apparatuses in use cannot be given in this paper, as it would be sufficient for a paper by itself, but some of the chief sources of danger, however, must be pointed out. First is the lead itself usually used in the construction. The combined action of nitric, nitrous and sulphuric acid on the lead is very great; but still greater is that of the fumes, when mixed with the outside air, because diluted acid attacks metals more than strong acid. The lead should be perfectly pure; some even prefer remelted old lead, as it becomes harder by remelting. If the slightest amount of zinc is present the lead is very soon perfectly honeycombed. The fumes should be drawn off

through a pipe with a good draught in it, so that the outside air cannot enter the vessel. The compressed air used for stirring and cooling should come from a storage vessel, where it can deposit all its moisture, and the pipes leading to the apparatus should ascend as much as possible, and have a drain-tap attached. All joints should be made quite tight, and the construction of the cooling worms must be well understood, as they will expand and contract, and can easily leak. It must be understood that the slightest leak of water pipe may start a very serious decomposition, and it is therefore a good plan to test the whole apparatus every morning before starting work.

The manner of introducing the glycerin is another matter for consideration. In some apparatuses where a screw paddle assists the stirring, the glycerin runs on a disk attached to it, and is therefore scattered by centrifugal force in minute drops. Sometimes a perforated pipe supplies the glycerin, and very often an injector. Those injectors which are placed near the bottom of the vessel are soon eaten away, and sometimes cause a sudden inrush of glycerin, which is of course to be avoided. Injectors or pressure vessels which blow the glycerin through a pipe are perhaps the best.

The temperature in the apparatus must be efficiently controlled; it is not sufficient to know the temperature of one part of the vessel only, since decomposition generally starts locally and then spreads over the whole mass.

The taps for discharging to the separators and to the safety tanks want very careful fixing, and it is commonly said that it is a knowledge of itself to make all the different kinds of mastic or cements that are required in a dynamite factory. Of course the taps must not be placed so that water can get into them. At the same time much depends upon what pressure there is on the tap, and one of the objections to those huge American apparatuses is that they have a column of acid 10 or more feet high resting on the taps, and exerting about 8 lbs. pressure per square inch. It is so easy to get a tap or a plug knocked out, apart from the pressure on the tank and the enormous weight of the cooling worms.

The apparatus should of course be made so as to empty itself to the last drop, and the safety tap should be sufficiently large to empty the vessel in a few minutes. Exactly the same remarks apply to the first separators and the bottles used in the secondary separation.

It might be appropriate to mention here that a decomposition in a properly constructed apparatus is a very rare occurrence indeed,

and due only to leakage, bad glycerin, or inattention on the part of workmen. Even if a decomposition should be seen starting, there is no need to drown a charge at once, or to lose one's head and run away. A decomposition, as has been mentioned, begins at one point and spreads gradually through the whole mass. A slight decomposition will develop a huge volume of dark red fumes, and is certainly alarming to the novice, but it will take sometimes ten or more minutes before it can develop into an explosion. The author has seen decomposing charges entirely saved by the coolness of the workmen, who freely used all the available means for cooling and stirring. In one instance, the acid underneath the nitroglycerin in a separator decomposed, and the man in charge, who was a new hand, in his confusion opened the nitroglycerin tap instead of the safety tap, and although the whole of the nitroglycerin had time to run into a water tank, it was more than a quarter of an hour before one could think of entering the building to drown the decomposing acid.

In the process of separating the nitroglycerin from the acids there is the danger of a prolonged contact of the two liquids, which has been fully investigated by the Home Office in reference to the Pembrey accident. Nitroglycerin dissolves in sulphuric acid, and just at the line of contact between the two liquids many of those lower nitro-compounds collect which have been formed from the impurities in the glycerin. Others collect on the top of the nitroglycerin, where they are exposed to the action of the air. Pure nitroglycerin can remain a very long time in contact with pure nitric and sulphuric acid without alteration; but in a process where everything is impure, the lower nitro-compounds are soluble and unstable, and therefore the separation should be finished as quickly as possible. I have referred already to the glycerin retarding the separation, but there are also mechanical impurities in the other reagents which have even worse effect. If the sulphuric acid contain much lead, if the mixed acids have been in the storage tanks too long, and some lead or iron is dissolved in them, this will be suspended in minute, but bulky, quantities in the mixture of nitroglycerin and acids which leaves the nitrating apparatus. Still more marked is this effect in the case of any carbonaceous matter introduced, such as straw from the carboys, gross organic impurities of the glycerin, etc. This is the case with the Boutmy-Faucher process, where, by dissolving the glycerin in sulphuric acid, the impurities in the former are charred and delay the separation in an extraordinary way. The

worst case known to the author was one when a second-hand air vessel was bought for the storage of sulphuric acid and a thick layer of rust prevented it being seen that the vessel had formerly been coated inside with tar. The sulphuric acid became quite black from the tar, and after two days' separation only half of the nitroglycerin could be recovered.

It must be understood that the difference of specific gravity between the nitroglycerin and the refuse acids is only 0.100, the former having a gravity of exactly 1.600 and the latter about 1.700, and although the greater fluidity of the acids facilitates to a great extent the separation, yet such bulky impurities remain for a long time suspended and form contact between the more sticky nitroglycerin and the acids, thus obstructing separation.

The secondary separator receives the spent acids, which generally contain minute globules of nitroglycerin in suspension, and it is essential that they should have time to separate. This secondary separation is the weakest spot in a dynamite factory. The fact that small quantities of highly acid nitroglycerin are floating on the top of strong acid, and, even with the best ventilating tubes, are exposed to the air, may account for some decompositions, but the author believes that a careful investigation of all the facts would nearly in every case point to another cause for an accident, that cause either a leak of a water-pipe or the intrusion of some organic matter.

Some of the experiments which the author has carried out with waste acids have shown that if large quantities of glycerin are poured into waste acid (which has nearly invariably the composition of about 10 nitric monohydrate, 70 sulphuric monohydrate, and 20 water), a turbulent decomposition takes place in a very short time. If we take the process of nitration to consist of an interchange between the NO_3 group of the nitric acid and the hydrogen molecules of the glycerin until complete exhaustion of the former, then every particle of glycerin entering in excess will not be nitrated, but dissolved in the sulphuric acid, as after the formation of the bulk of nitroglycerin the nitric acid left occupies about one-fourteenth of the whole mixture, and in spite of violent stirring it is difficult to cause the little nitric acid remaining to come in contact with the glycerin particles. Besides, this nitric acid, as it is seen from the composition of the refuse acids, is in a very diluted state, and if it could easily come in contact with the glycerin, it would only form mono- and dinitroglycerin, which are soluble. Thus it will be seen

that an excess of glycerin forms a very dangerous mixture, and on two occasions at least the cause of decompositions could be distinctly traced by the author to such an excess.

It must be pointed out that a small excess of glycerin may happen with any operation, as it is impossible to calculate exactly the quantity required, and a slight variation in the strength of the nitric acid will at once alter the quantity of glycerin which can be converted into trinitroglycerin.

There is another reason why very strong acid with a rather higher percentage of nitrous acid is preferable to the reverse, as the workman can guard against overheating, but he has no means of ascertaining the total nitrating capacity of the nitric acid. But a small excess of glycerin, although just affording the amount of danger connected with the work, is still not a distinct danger, so long as proper attention is paid. It is only a large excess which can produce a sudden decomposition, and it would be impossible to stop this. This excess of glycerin need not necessarily be the consequence of an error in weighing, it can also be brought about by using too weak nitric or sulphuric acid, or by a mistake in weighing the acids for mixing. The only remedy in this case is to watch the yield of nitroglycerin. If it falls below a certain limit, then part of the glycerin must have escaped nitration, and the only plan to adopt is to at once drown the waste acids, as containing too much glycerin. With good yields of nitroglycerin and proper attention the secondary separation never gives any trouble.

As the waste acids are in most cases treated in a denitrating apparatus to recover the two component acids separately, care must be taken that every particle of nitroglycerin is removed in the storage tanks before working them up. Small drops may come up after days, and an explosion of a denitration plant in Italy was due to neglect in this direction. The storage tanks must also be protected against the weather, and have a safety tank attached, as their contents will sometimes decompose, especially in hot climates.

In the operation of washing and filtering the nitroglycerin, warm water should be used with caution, as nitroglycerin begins to evaporate at 104°, and the inhalation of nitroglycerin vapors in large quantities is injurious.

The other operations do not require more attention than with other explosives, except the formation of cartridges by lever presses, where the material falls through a funnel into a tube, and a piston on

a lever forces the dynamite out in the form of a cylindrical mass. There are two kinds of presses, one where the parchment paper is wrapped around the tube and the whole cartridge is made in one pressing, and others where the dynamite is pressed out by consecutive strokes with the lever, so that a continuous string comes out of the tube. This is broken off when it reaches the required length, and then wrapped round with parchment paper. This kind of intermittent pressing is no doubt the best, and the single stroke presses are rightly objected to by the German industrial inspectors. It is patent that in order to press out a cylinder of soft material of about four inches in length there is perhaps twenty times more force wanted than for a piece of an inch, and any metal or grit particle, or even a hard lump of kieselguhr, may produce enough friction on the tube to cause an explosion. By far the majority of the explosions in cartridge huts happened with single stroke presses. Of course, cartridge presses must be so constructed and secured as to prevent any hard blow or friction.

The manufacture of blasting gelatin, gelatin dynamite, and gelignite calls for very few remarks. As the process is carried out with the aid of artificial heating, care must be taken to avoid excessive heating, since the collodion-cotton may begin to decompose and the nitroglycerin to evaporate. The machines for mixing, if such are used, and for making cartridges must be so constructed as to avoid undue friction, and to allow of ready inspection and cleaning.

The danger of freezing has still to be dealt with. It is well known that nitroglycerin freezes at about 46° F. Dynamite and blasting gelatin will freeze at slightly lower temperatures. Numerous experiments have shown that frozen nitroglycerin and dynamite are highly insensible against a shock, and that even a bullet fired from a military rifle at 50 paces has failed to explode it, whereas soft dynamite explodes readily at 300 and more paces. Yet somehow frozen nitroglycerin does sometimes explode. To the author's own knowledge, the removing of some frozen nitroglycerin from the ground by means of a pickaxe, the sudden turning of an earthenware tap, around whose plug some nitroglycerin froze, the cleaning of vessels containing frozen refuse, and even the forcible breaking of a frozen dynamite cartridge, have resulted in explosions, and it is probable that similar instances are known to others. The author believes that the explosion of frozen nitroglycerin is due to a sudden alteration in the molecular arrangement of the frozen nitroglycerin—such as Professor

Tyndall stated in the case of ice—and the consequent production of vibrations sufficiently high to cause a detonation. This is certainly a striking illustration of the fact that explosion is not merely a result of heat.

Blasting gelatin and gelatin dynamites, on the other hand, are extremely sensitive in a frozen state, which is solely due to the collodion-cotton. In the soft gelatinous state, of course, every shock is annihilated, and the gelatins are in fact indifferent in this state; but when the gelatin is frozen and forms one rigid, hard mass, a blow will be readily communicated throughout the whole mass, and the collodion-cotton will be the first to explode. It is therefore of high importance that the nitroglycerin or dynamite should never be allowed to freeze during manufacture. Even in moderately warm rooms the cold earthenware taps may cause freezing, or drops of nitroglycerin spilt on the floor may become hard, and the danger of working frozen dynamite in cartridge presses is very great. It has repeatedly happened that small crystals of frozen nitroglycerin "cracked" on a wooden floor by being rubbed with a leather shoe.

The sun has a decided effect on the nitroglycerin, inasmuch as the heat generated will decompose it. This is the reason why the roofs and windows should be painted white, especially the window-panes, as they will usually contain some faulty spots which act like lenses. The action of the sun on nitroglycerin that had been inadvertently allowed to run away in the sand has several times produced explosions.

The refuse resulting from the sweepings, the residues on the filters, the mud in the deposit of washings, etc., have to be carefully burned. This refuse, or even defective dynamite, if laid out in a train and ignited, will burn quietly for some time, but then suddenly explode. The author is indebted to Dr. Dupré, F. R. S., for the hint that by pouring paraffin oil over such refuse it can be burnt without fear of explosion.

Although all the possibilities of danger have not been mentioned, and although perhaps the long list may have alarmed you, yet the author confidently asserts, from personal knowledge and long experience, that the manufacture of dynamite is far less dangerous and certainly less subject to sudden and unforeseen accidents than that of gunpowder, which has a record of casualties for more than five centuries.

Smokeless Powder.—The manufacture of smokeless powders has within the last four years come to the foreground, and is in many instances similar to that of the gelatin-compounds. As it is a comparatively new industry, chiefly in the hands of governments, and as none of the powders can yet claim to have reached the stage of perfection, it may seem to be superfluous to enter into many details. The fact that nearly every factory has some process of its own, because every one is anxious to keep his own experiences secret, makes general remarks very difficult.

Smokeless powders are practically of two kinds, those made from gun-cotton and a solvent only, and those made from nitroglycerin and gun-cotton with or without the aid of a solvent. Of late nitrated starch seems to be favored. As a solvent, acetone is now generally used, and the process of dissolving the gun-cotton, or making a gelatin of nitroglycerin and soluble gun-cotton, with or without the subsequent addition of insoluble gun-cotton and camphor, does not want any special allusion, as the machines for incorporating the materials are about the same as now used for the manufacture of blasting gelatin. But the subsequent working up into small square sheets or round disks, in imitation of the manufacture of certain pastries, requires more attention, although it must be said that the acetone, of which traces always remain in the powder, renders it comparatively safe. The jelly-like incorporated mass when leaving the mixing machine is subjected to a partial evaporation, and then passed through steam-heated rollers to be rolled into sheets, and at the same time to evaporate all the acetone. In these rollers small local explosions sometimes take place, which are probably due to some undissolved gun-cotton being submitted to heat and friction, but which pass away without doing any harm. Great care has to be taken to collect the acetone vapors, as they are explosive and may spread over a large area. The cutting of these sheets into small squares is also without special risk, as the pressure on the sheet is small, and no undue friction is likely to occur. Of course the powder should not be allowed to accumulate, as, although considerable quantities of it can burn without explosion, yet the fire spreads quick enough to cut off escape, as has been proved at a fire in an Italian factory. The manufacture of cordite, the British smokeless powder, varies in some stages from that of others, and being the invention of Sir Frederick Abel, and manufactured under his superintendence, does not call for further remark in this paper on the dangers of explosives.

The stability of smokeless powders with regard to atmospheric and climatic influence has still to be conclusively tested.

Other Explosives.—Nitrobenzene is, I believe, no longer used with explosives; its manufacture is well known, and is only dangerous during the nitration and through the poisonous effects of its fumes.

The manufacture of picric acid is also to a certain extent outside the scope of this paper. It presents no danger, during the manufacture proper, but the finished product, when mixed accidentally with certain materials, as lime, nitrate of lead, etc., will produce a detonating mixture, as has been successfully proved by Colonel Majendie and Dr. Dupré in their report about an explosion in Manchester.

Under the name of "Melinite," "Lyddite," "Ecrasite," etc., picric acid has been used for filling shells. Picrate of ammonia, trinitrocresol and the ammonia salt of it are also used. They are melted in a hot water bath and filled into the shells. They are exploded generally by a primer of gun-cotton. As this work is only carried out in military establishments, further consideration is not necessary before this Society. Neither is it necessary to enter into the details of manufacture of roburite, securite, ammonite and similar products, or fireworks. The processes used with the former are very much the same as those used in other manufactories of explosives. In the manufacture of fireworks the preparation of the different mixtures, the compression into rockets, the distribution of pills for amorces, etc., can with little modifications be governed by the considerations applicable to gunpowder factories. Only the frequent use of chlorates, especially Chertier's copper, calls for attention as the cause of many decompositions, and all chlorate mixtures are extremely sensitive to shock and friction. Of course, if the mixture is moistened to form a paste, it will stand a great amount of shock, but when too much water is added, some particles may become exposed to the direct action of the blow.

The last explosive to be mentioned, before discussing the dangers in conveyance and use, is fulminate of mercury, which is used for filling caps and detonators. The manufacture is simple enough, and with ordinary precaution no accident should happen. Of course the ebullition after the addition of alcohol has to be carefully regulated, and attention has to be paid to the way the developing vessels are carried about, the fume-pipes put on, etc.; the nitrous ether formed should also be condensed away from fire. The washing of the fulminate should be well attended to, to avoid decompositions,

and the ready-made fulminate should be stored with not less than 20 per cent. moisture. It is chiefly in the working up of the fulminate where the danger comes in. As to drying it, the ordinary precautions as to heating by a current of air, absence of metal in the room, having hair rugs or india-rubber mats on the floor are sufficient.

The mixing of the fulminate with nitrates, chlorates, ground glass, etc., is perhaps the most dangerous part, as thereby a large amount of friction is produced. The process used at Woolwich is certainly the safest, and will give a better mixture than the usual work with a feather. It consists essentially of a silk bag on which there are diagonally placed india-rubber disks, like a string of pearls. To the bottom of this bag is fastened a thread, which is moved by a lever from behind an iron screen, thereby taking up and throwing down the fulminate between the disks. No explosion has happened at Woolwich since the introduction of this ingenious mechanism some years ago.

The filling of caps with the fulminate is done everywhere by carefully planned machines, which avoid friction and overcharging. The compression of the priming composition is best made in molds attached to separate weighted levers for each cap, so that in spite of the probable inequality of filling, each charge should only receive the same pressure as the other. In some factories the whole press is sheltered by a screen which is automatically closed during the compression, and no composition is allowed to be in the room.

In fulminate factories proper precautions must be taken against any possible friction. These are briefly the use of hair rugs, felt slippers, frequent washing and dusting of floors and rugs, preventives against spilling of material, etc. Like other mercury substances, fulminate is injurious to the body, especially the gums of the teeth, if too much dust is produced and ventilation not efficient.

This is the only country, to the author's knowledge, in which the exclusion of iron from the interior of the buildings, the absence of so much as a few grains of mud or grit on a floor, and in general the cleanliness throughout are rigorously enforced. It certainly made a great stir amongst the manufacturers when the Explosives Act came into operation, but seldom was there on the whole a wiser measure taken. If one remembers that last year only in one gunpowder factory were there fatal accidents, and that the mortality amongst the workmen in explosives factories was not larger than that in all London, you will agree with the author that the Explosives Act was

very beneficial and that the inspectors who carry it out are doing most useful work. It is certainly not the absence of a little grit, because in thousands of cases it will be of no harm, but the general spirit of the order, cleanliness and precaution instilled to the workmen which makes a factory safe.

According to the Explosives Act, every danger building must be provided with an efficient lightning conductor. In spite of the Lightning Rod Conference, in which so many eminent men took part, the question as to what forms an efficient lightning conductor is yet undecided. A lightning conductor is a good and useful instrument on a dwelling-house where an accidental disturbance in the arrangement may not do great harm, but the case is entirely different with a workshop or a magazine for explosives. The thorough and reliable examination of a lightning conductor can only be done by an electrical expert, and in a factory where sometimes 100 of them have to be tested this takes several days. Yet, if a gale is blowing, or the factory is exposed to the influence of sea-atmosphere, the lightning conductor is soon out of order again. Then take the presence of machinery in the buildings, tram-lines, pipe-lines overhead and underground, and you will find that a lightning conductor is not only a very limited preventive, but very often a positive danger. Without further entering into this question, the author thinks that a competent investigation of this subject with reference to explosives factories would be very beneficial.

A great many factories are now lit by electricity. Since this paper was written, special regulations in regard to electric lighting in explosives works have been issued by the Home Office. I do not wish to criticise these regulations, as too short a time has elapsed, and their effect cannot yet be appreciated. I will therefore only give my own experience. It is highly important that suitable lightning conductors should be attached to the circuit. From experience, the author knows of two cases where the lightning struck into the wires, which were carried overhead. The wires should always enter a building from opposite sides, so as to prevent accidental short circuits, and no joint or switch should be allowed inside the building. The lamps should invariably be surrounded by a tightly fitting large glass globe, which allows sufficient radiation of the heat. Although the heat on the outside of the lamp is scarcely larger than 120°, yet, if a lamp be covered with explosive dust and the heat cannot radiate into the open air, there will be such an accumulation of heat that serious accidents

may occur. As to an excess of tension in the current, the best plan is to have an arrangement whereby in case the tension rises over a certain limit the whole of the plant is cut out of circuit. It is by far preferable to have the place in darkness than to see sparks traveling along the wires.

It would be quite possible to write a paper by itself about the dangers in connection with the use of explosives in mines. Miners will frequently insist on treating explosives with the greatest recklessness, and if it were not as a rule accompanied by a loss of life or limbs, I would be able to write quite an amusing paper about the innumerable ways in which the miners handle explosives. Carrying gunpowder in open boxes, with a candle on the hat or in the hand, squeezing detonators with the teeth, charging bore-holes with boring bars, thawing dynamite on a hot stove, or even on an open fire, in a straw hat, are cases that frequently occur. It will still take a long time before anything like proper precaution will be taken everywhere.

The carriage of explosives, whether by road, vessel, or rail, is under ordinary circumstances free from danger. No explosive is licensed which does not in itself present a certain degree of safety, and the packing is so substantial that unless the packages are very roughly handled not even a spilling of explosive is likely to occur. For this reason, in almost every country the carriage of explosives by rail is allowed. Of the more important countries, Great Britain alone makes an exception as regards gun-cotton and dynamite, but why cannot be said. The railways will carry gunpowder, detonators, blasting gelatin and gelatin dynamite, but not gun-cotton and dynamite. Gun-cotton is always sent with from 20 to 30 per cent. moisture, in which state it cannot be exploded by ordinary means. Dynamite is no more dangerous than gelatin dynamite, and in the 20 years during which it has been carried on Austrian railways not a single accident has occurred. Let us hope that here also this obstacle will soon be removed; it injures the railways indirectly more than anybody else, as they are the largest consumers of coal and iron, which cannot be won without the use of explosives.

In discussing this paper Mr. Arnold Philip said that some 18 months previously, in going over a large dynamite works, he had seen a plant employed for the recovery of the acids which had been used in the manufacture of nitroglycerin. This apparatus consisted in part of two scrubber towers, apparently built of flags

of sandstone held together outside by iron tie-rods; inside they contained coke or some other suitable material on which to condense the acid fumes. The waste acids were heated in stills connected with the scrubbers; there was, however, some difficulty in employing this apparatus, for explosions were not infrequent. These explosions were usually slight in character, and chiefly occurred in the scrubbers, but they caused considerable financial loss by the damage which they caused to this part of the plant. All the trouble was due to the minute amount of nitroglycerin which remained in the waste acids even after they had been allowed to stand and settle for a very considerable time. On account of this difficulty there was a natural disinclination on the part of the manufacturers to distil waste acid, and it was not at all an uncommon thing in nitroglycerin factories for tons of it to be thrown away. If, however, these traces of nitroglycerin could be satisfactorily removed, the acids might afterwards be recovered, and a great saving thus introduced. It was possible that this might be done by dissolving out the trace of nitroglycerin by means of paraffin. Of course the strength of the acids in question made it quite impossible to employ either hydrocarbons of the benzene series or ether for this purpose. With regard to the question of lightning conductors, it would be interesting to know whether Mr. Guttmann had had any experience with Prof. Oliver Lodge's method of protecting buildings; this was based on the same principle on which electrometers were sometimes shielded by wire cages. Professor Lodge proposed to cover buildings with what was practically a network of galvanized iron wire. This material was of course far cheaper than copper or any copper alloy, and although not so good a conductor, yet for electric discharges of such high potential as lightning, so long as there was a metallic conductor, it really mattered very little whether it had a high or low conductivity.

Mr. de Mosenthal said that he believed that Dr. Dupré's experiment with the broomstick was correct only so far as chlorate of potash explosives were concerned. Referring to the question of lightning conductors, an explosion due to lightning had occurred quite recently in a manufactory on the Continent, where the rod had been examined by an expert a few days only before the explosion occurred, and was therefore probably in perfect order. In that case the conductor was placed on the earthworks which protected the building, but it was generally supposed that the position of the con-

ductors was immaterial. As Mr. Guttmann had pointed out, very little was known about the subject; and it was to be hoped that the report of a Special Commission which had been at work in Germany for something like two years would throw further light on the subject.

Lieutenant-Colonel Cundill remarked that last year only one fatal accident had occurred due to the manufacture of explosives. He thought that statement spoke volumes for the care exercised by the manufacturers. His department was much indebted to the trade for the way in which any suggestions made by them before the Explosives Act came into force had been carried out. The average number of deaths in England and Wales alone caused by explosions in manufacture in the seven years preceding the introduction of the Act was 39.5; the average was now something under eight for the United Kingdom. In 1890 there were eight deaths, but those were all in one factory; and the accident which caused the one death in 1891 was due to a man hammering a cast-iron die-plate with a steel punch in a building where there was gunpowder, this being a flagrant violation of the statutory rules.

After some observations from Mr. Otto Hehner, Mr. Guttmann in reply said that the suggestion of Mr. Philip to use paraffin for effecting the better separation of nitroglycerin from the waste acids had not, to his knowledge, been tried with nitroglycerin, but it had been tried with picric acid. He knew of a case where it had been used for many years for separating the picric acid, but he had recently seen a sample of a compound which had been found during such separation, which was a dangerous one. He had been asked to make experiments with this substance as an explosive, but it smelt so decidedly acid that he requested that it should be taken back as soon as possible and washed. He had carefully considered Professor Oliver Lodge's system of lightning conductors. The idea, however, was not new. A Belgian (Mr. Melsens) was the first to make lightning conductors in that manner. Professor Zenger, of Prague, had developed it, and it had been extensively tried by the Austrian military authorities. In that country, in the mountain region of the Karst, a thunderstorm occurred nearly every day, and the lightning struck everything above ground. They had a number of exposed forts and military stores there, containing gunpowder, ammunition, ready-made shells, etc., and it was not a pleasant feeling to find these things exposed to such thunderstorms. They had

tried the wire-cage system and it was found to be a very effective protection. Colonel Ph. Hess placed in such a cage one of the bridge detonators employed for military purposes, which are so sensitive that the smallest amount of electricity would fire them, and he could not get an explosion although he applied the sparks of a Wimhurst machine. So far no more had been heard about the practical application of this system. As to Mr. de Mosenthal's observations, he would just mention that the broomstick question had been discussed in that room by Dr. Dupré. If he remembered rightly, it was in connexion with kinetite, an explosive which it had been attempted to introduce in this country. For a long time the English government would not pass it, on the ground that it was not safe. This the agent of the firm who introduced the explosive tried, in that room, to explain was not the case. He remembered reading Dr. Dupré's speech on that occasion, in which he stated that everything in the hands of a man who was willing went all right, but that if any person who was not conversant with the matter struck the substance with a broomstick on a wooden floor it would go off. He believed that any explosive which Dr. Dupré had tested did not fail to explode when struck with a broomstick. Lastly, he would deal with Mr. Hehner's observations. He (Mr. Guttmann) had often discussed the question of glycerin with Mr. Hehner, and he was aware that Mr. Hehner held that a small quantity of chlorine, acid, or aldehydes in glycerin was not very important; yet he believed he expressed the opinion of manufacturers when he stated that they held the opposite view. Mr. Hehner had said that experience was the principal thing to be taken into consideration, and the experience of manufacturers showed that the presence of chlorine developed hyponitric acid, a body the formation of which they desired to avoid as much as possible. The same remarks applied to aldehydes and poly-glycerins. It was probably these constituents that formed the amount of organic matter in the residue. If one per cent. of organic matter was present in the residue, there was sure to be a smaller yield of nitroglycerin and a larger development of nitric peroxide.

In his study of the "Explosive Properties of Trinitrotoluene," C. Hausserman has made various experiments to test the safety and suitability of this body as an explosive, and he states that there are no difficulties and dangers in its manufacture which could hinder it from entering the field with other explosives. In order to test its stability

when kept for some time he exposed portions of this body in the air for several months to varying temperatures (—10° to + 50°), and found that when the trinitrotoluene had been crystallized from alcohol, only a slight surface yellow color was noticed, and no change could be detected in any of its other properties; but when the body had only been freed from acid by washing with water and dilute soda and allowed to stand a short time, traces of acid vapors were frequently detected by the "heat test." Some of the trinitrotoluene was rubbed in an iron mortar, alone and mixed with sand, and no change was observed. On striking it on an anvil, only a very slight decomposition could be detected, and this did not give rise to a report or any appearance of fire. Further experiments showed that trinitrotoluene could not be exploded by flame or by heating in an open vessel in the air. Heated on platinum foil it first melts, then evaporates and catches fire, burning quietly with a very sooty flame. Projected on to a red-hot iron plate it simply burns rapidly. When heated in a test-tube it boils at 300°, and if the heat be continued it froths up and catches fire, leaving a large porous carbonaceous residue. Only when a large mass is rapidly heated in a covered vessel does feeble detonation take place, and this produces very slight effects. Seventy grammes of the powdered substance were placed in a closed cubical zinc case, the sides of which measured 4 cm. This case was placed on a cast-iron plate 2 cm. in thickness, and was fired by a fulminate detonator 35 cm. in length. The explosion was accompanied by a loud report and a distinct, although faint, cloud of smoke. The iron plate was quite destroyed and pieces of it scattered widely. Further experiments showed that it belongs to the class of shattering explosives. A mixture was also made of 1 part of trinitrotoluene and 3½ parts of ammonium nitrate. Comparative experiments showed that this mixture did less mechanical work on explosion than the trinitrotoluene alone, but more than a corresponding mixture of dinitrobenzene and ammonium nitrate. It is pointed out that the manufacture of an explosive by mixing trinitrotoluene and ammonium nitrate does not give rise to injurious fumes, as in the case of dinitrobenzene.—*J. Soc. Chem. Ind.*, **10**, *1028*; 1891.

Berthelot and Matignon (Compt. rend., **113**, *246-249*), in studying the Heats of Combustion and Formation of Nitrobenzenes, have obtained the following results:

	Heat of combustion, constant volume. Cal.	Heat of combustion, constant pressure. Cal.	Formation from elements. Cal.	Formation from nitric acid. Cal.
Orthodinitrobenzene	+704.6	+703.5	+0.5	+58.3
Metadinitrobenzene	+698.1	+697.0	+6.8	+64.8
Paradinitrobenzene	+696.5	+695.4	+8.4	+66.4
Trinitrobenzene (1:3:5)	+665.9	+663.8	+5.5	+90.9
Trinitrobenzene (1:2:4)	+680.6	+678.5	−9.2	+76.2

It is clear that although the values for the various isomerides are very similar, as is usually the case, there are distinct differences, amounting to 1 per cent. in the case of dinitro-derivatives, and to 2 per cent. in the case of trinitro-derivatives. The differences are also distinct in the case of the formation from nitric acid, and the heat developed becomes less the more advanced the substitution.

The heat of formation of a nitro-derivative is always but slightly different from that of the generating hydrocarbon; and it follows that the oxygen of the nitroxyl group has nearly the same combustible power as if it were in the free state. Since the heat of formation becomes less as nitration advances, it follows that the combustible energy of the oxygen gradually increases. The bearing of this result on the explosibility of nitro-derivatives is obvious.

A. Huber, in studying the Physiological Action of Dinitrobenzene (Virchow's Archiv, **126**, *240–270*), finds that the main effects of dinitrobenzene, as tested on both cold- and warm-blooded animals, are changes in the blood, paralysis and intense dyspnœa. The blood becomes of a dark chocolate color; the red corpuscles are largely deprived of their pigment, which in frogs partly collects round the nucleus. Spectroscopic investigation showed an absorption band in the red, reminding one of the similar band of acid hæmatin, and of methæmoglobin, but not identical with either. It is spoken of as the dinitrobenzene band, and it is considered that this compound acts in a specific manner on the blood pigment. After large doses, the urine was found to be brown in color, and to contain a strongly reducing substance, and sometimes dinitrobenzene was itself present. The body temperature is lowered. The illness which workers in roburite factories suffer from appears to be caused by dinitrobenzene fumes.

"The Explosive Properties of Ammonium Nitrate" have been examined by C. A. Lobry de Bruyn, and from the results published in *Rec. Trav. Chim.* we extract the following:

Ammonium nitrate is a component of many explosives which are but slightly sensitive to ordinary mechanical shocks, and are difficult of ignition, although by the detonation of small quantities of mercuric fulminate they are rendered explosive. Berthelot (*Abstr. J. Chem. Soc.*, p. 453; 1882) and Thorpe (*Trans. Chem. Soc.*, p. 220; 1889) prove that endothermic combinations decompose explosively under the influences of mercuric fulminate, and it is well known that explosives require a variable initial impulse to cause their decomposition. The author describes the following experiments which were made with shells of 8 cm. caliber, weighing 7 kilos., and capable of holding about 200 grammes of explosive. The force of the explosion was estimated by the number and weight of the collected pieces and the distance to which they were scattered; the difference between this weight and the original weight being reckoned as shell reduced to powder by the explosion. In the case of black gunpowder fired electrically by a platinum thread, 10 pieces were collected whose collective weight was nearly that of the original shell, but, when a fulminate cap was used, 77 pieces whose collective weight was but 3.8 kilos. was obtained. When shells filled with bellite, dynamite, and cotton-powder were exploded by means of 1 gramme of mercuric fulminate, the shells were reduced to powder. One gramme of mercuric fulminate produced no effect on a shell filled with ammonium nitrate, except to evaporate a small amount in the immediate vicinity of the fuse, whilst the screw holding the shell was moved. Three grammes of fulminate caused a low, rumbling explosion, and 62 pieces of shell were collected which weighed 6 kilos. A shell containing 180 grammes of ammonium nitrate and 20 to 30 grammes of bellite (composed of dinitrobenzene 1 part and ammonium nitrate 4 parts) yielded, on explosion by 1 gramme of mercuric fulminate, 230 pieces weighing 2.75 kilos. Hence it appears that ammonium nitrate requires a stronger initial impulse than either dynamite or dry cotton-powder; that its employment, unless it be mixed with charcoal or aromatic nitro-compounds, is negatived on account of its weaker action, although for coal-mining purposes its employment would seem to be advantageous, as but a slight rise in temperature accompanies the explosion.—*J. Chem. Soc. Abstr., 683;* 1892.

Among recent works are to be noted "Études de Tactique,"* by General Lazeux, which deals with the consequences of the adoption

* pph. 8vo, 63 pp. L. Baudoin et Cie., Paris, 1890.

of smokeless powder and of rapid-fire, small-caliber guns; "La Fortification Permanente et les Explosifs en 1890–1891," * by Capitaine G. de' S., which treats of the effects of nitro-substitution explosives in shell on fortifications, giving the results of experimental trials; "Die gepresste Schiesswolle," † by Franz Plach, which is an excellent brochure on the properties, preparation and methods of using military gun-cotton for torpedo work, and is especially novel in its illustrated description of the means of forming charges for the heads of auto-mobile torpedoes from service blocks; "Blasting," ‡ by Oscar Guttmann, which devotes some 60 pages to the properties of modern explosives and contains descriptions of a new apparatus for testing the force of explosives; "Miner's Pocketbook," § by C. G. Warnford Lock, which gives some useful information on explosives for mining; and "Machines pour fabriquer la poudre," ‖ which is a trade catalogue.

* pph. 8vo, 63 pp. Henri Charles-Lavauzelle, 1892.
† pph. lg. 8vo, 133 pp. 24 ill. Pola, 1891.
‡ lg. 8vo, 179 pp. 136 ill. Charles Griffin & Co., London, 1892.
§ 472 pp. Spon & Chamberlain, N. Y., 1892.
‖ pph. 8vo, 52 pp. 14 ill. Grusonwerk, Magdebourg-Buckau.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL SIGNALING.*

By A. P. NIBLACK, Lieutenant, Junior Grade, U. S. Navy.

DISCUSSION.

Lieutenant S. A. STAUNTON, U. S. Navy.—Mr. Niblack advances many views with regard to signaling in which I heartily concur, and a number to which with equal heartiness I take exception; and as, in a discussion of his paper, it is naturally the criticized views which receive attention, I shall devote my remarks chiefly to the latter class.

The essayist has sent to the Naval Institute several papers on this subject. I have read them all with attention, and I have traced in them a growing tendency to the adoption of certain opinions upon the theory of signaling which are formally set forth in the paper now before us.

It is of advantage to the discussion that the text has appeared, for it gives a definite point upon which to join issue; and I consider the fundamental principles underlying naval signaling to be of great importance. Mr. Niblack says, p. 461: "The writer holds that the Myer code, using with it the four-element numeral code proposed, is the ideal naval signal code, adaptable to all modern conditions; also that the code is of the first importance, and that the means of transmitting it is somewhat secondary."

"Somewhat secondary" is a little undecided; but the tenor of his paper shows plainly that the code employed is, in his opinion, of an importance to which everything else must yield.

This position is, in my opinion, fundamentally unsound. To place the code before the choice of elements and the method of transmitting them, is to place the cart before the horse. My own estimate of the true theory of a system of signals, either day or night, is first to choose suitable elements, and the best method of transmitting them, and then to arrange those elements into the most convenient and suitable code permitted by their number and character. The number and character of elements and their method of transmission are so intimately associated that they cannot well be separated. If the movements of a single flag in the hands of a man are to be the symbols of the elements, their number is best limited to three, as in the Myer system, and their character

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to right, left, and front movements. A semaphore arm gives a greater number of distinctly separate and easily recorded positions, and therefore a greater number of elements can be employed. The Very signals again are limited to two elements, because only strongly contrasting colors are admissible in signal lights which are to be read at great distances. The Ardois signals have 62 elements or groups of lights. The number of elements of a flag day system of signals is limited only by the number of flags which, in color and shape, are distinctly recognizable at ordinary distances; and, in practice, the number of elements in a flag code ranges from ten to twenty, besides auxiliaries.

I repeat these well known facts because I wish to call especial attention to the great practical scope of this matter of naval signaling, and to impress upon the members of the Naval Institute my belief that codes must of necessity vary with the signal systems employed.

My experience as flag lieutenant and signal officer of the Squadron of Evolution has taught me the supreme importance of choosing symbols or signal elements that shall be easily distinguished, and of transmitting them with certainty and precision, and with all possible rapidity; and that the code, or arrangement of those elements in combinations to represent numerals, letters, words or sentences, is secondary :—not "somewhat" secondary, but decidedly secondary. This is my text, and it is on this ground that I take issue with the essayist.

Crossing the Atlantic in December, 1889, before the Ardois signals were obtained for any of the new ships, I remember spending half the middle watch one night trying to send a short signal to a ship not a mile away. The ordinary torch, which at that time represented our total achievement in squadron night-signaling, sputtered, threw turpentine, and repeatedly went out after the manner of its kind.

I went back to my berth, chilled, disgusted, and smelling of turpentine; and a few experiences of that kind satisfied me that the "method of transmission" is secondary to *nothing* in a signal system.

I do not find the least objection to Mr. Niblack's preference for the old Myer code over the Continental Morse or the American Morse. But I object to making a fetish of any code, and to the assumption that a system must stand or fall upon the number of its elements and upon the manner in which these elements are combined, which in signal parlance is called its *code*. I do not mean to say that the code is unimportant, but that it is of secondary importance. A careful choice of elements must be made or, under unfavorable circumstances, they cannot with certainty be distinguished from each other. The method of transmission must be satisfactory, or the elements cannot be read at all. Nothing can be sacrificed to these prime requirements. The code comes after them in logical sequence; for the code cannot be utilized—has no value whatever—until the elements employed in it are observed and recorded. The combinations of elements forming a code have no more meaning to a signalman who, through defective choice of elements or defective transmission, has been unable to correctly take in a signal, than would English words written in German or Russian characters have to a school-child.

THE ASSIMILATION OF CODES.—I quite agree that it is desirable to assimilate the codes of different signal systems, in order to simplify the whole subject and to increase the general knowledge of signaling; but this parallelism should never be carried to a point where it infringes upon more important considerations. The value of a complete assimilation of different codes is largely theoretical; not, in my opinion, amounting to much in practical signaling. The position assumed by Mr. Niblack that every officer and man will thus learn to signal is not sustained by the experience of actual service, in our own navy or in any other. I admit that a great many men and boys may learn to make and to read signals slowly and imperfectly; but only those who stand upon the signal bridge day after day become efficient and are to be trusted. To secure good results it is necessary to make it a vocation on board ship. It is one of the weak points of our service that we have not yet established any signal rates in which men can qualify and re-enlist. The essayist recognizes this deficiency in his paper entitled "The Signal Question up to Date," published in No. 61, Proceedings of the Naval Institute, in which he strongly recommends that signalmen should be rated ranking with coxswains, and paid $30 per month; and that quartermasters be paid $35, and chief quartermasters $50.

Mr. Niblack was instructor in signaling in the Chicago during a great part of the first eighteen months of her cruise, and a very competent and painstaking instructor—thorough in that as in all other professional work; but the boys of his class when first put on the regular signal detail—and the best were always taken—required a good deal of practice at serious and responsible signaling before they became expert and trustworthy.

It is fallacy to assume that all hands in a ship will learn practical signaling; and an argument based upon such assumption is not sound. In the days of the old Myer code only a few people ever really knew how to signal.

Any convenient and rational code is quickly learned by men who constantly use it. The Ardois system has 62 elements or groups of lights. It is not strictly necessary to memorize them, as they are marked on the transmitter and are therefore directly before both the man who is sending and the one who is receiving the signals. But the signalmen soon learned them by simple use and repetition as a child learns the alphabet, and would call them out when displayed without reference to the keyboard.

More than this: ships not supplied with the Ardois were furnished with the description and instructions and were required to take in the Ardois signals with the remainder of the squadron, answering the call and the signal with Very lights; and the elements of the Ardois are so distinct, and their transmission so methodical and excellent, that no difficulty was experienced from the first.

It cannot be too forcibly stated that facility and expertness in the use of any system of signals comes only by habit and practice. A man who receives an hour's theoretical instruction a week, and quarterdeck practice at conversational distance, will halt and bungle with the simplest system; while a man who takes his regular watch on the signal bridge of a ship cruising in squadron

speedily becomes accomplished in the most amplified code. This fact has perhaps failed of its due impression because we have had so little squadron practice; but it is a very real fact. The value of a signal system is not to be determined by theoretical considerations, however pleasing and harmonious, but by its efficiency in practical service. It is a "condition and not a theory" with which we are dealing.

THE ARDOIS SYSTEM OF NIGHT SIGNALS.—The weight of Mr. Niblack's disapproval falls chiefly upon the Ardois. He deals it such blows as the following:

"Why the original Myer code was not used with the Ardois apparatus is difficult to conceive"—p. 451, note.

"The so-called Ardois alphabet violates most of the principles of a good code"—p. 451, note.

"These criticisms are only meant to bring out strongly the important fact that it is not safe to violate the fundamental principles of signaling in the construction of a code"—p. 441.

"An extremely objectionable and unnecessary code"—p. 477.

"Codes that violate every principle of signaling"—p. 478.

And yet with all this reiterated and strenuous abuse of the present Ardois code, the essayist fails to tell us why it is ojectionable and fundamentally wrong. I have looked carefully through his paper and I find therein no reason for condemning the Ardois code except that it cannot be assimilated to the Myer code, which he chooses to establish as a model.

A sketch of the history of the Ardois signal apparatus in our navy will not, I think, be out of place here.

It was introduced into the Squadron of Evolution two years ago. Upon the urgent representations of Rear Admiral Walker, the Chief of the Bureau of Equipment consented to order six sets from Sautté, Harlé and Co., the makers in Paris. In his efforts to obtain this signal, Lieutenant Buckingham and myself, then on Admiral Walker's staff, gave him every assistance in our power, and we were directed by him to present a scheme for marking the keyboard; in other words, to prepare the code. The manufacturers had somewhat modified the original Ardois system, employing all the possible 62 combinations, and arranging them in their present order. It only remained to attribute to the several displays the desired meanings and values.

Each display is an element. The Ardois is a system of 62 elements, and not of *two* elements, although lights of only two colors are employed. The lights of each group are turned on together by a single motion of the transmitter, and are turned off together when answered. With a two-element system, the successive displays of the elements necessary to form a group which represents a letter or a figure require proportional time. It takes four times as long to represent "K," for example, by the Myer code as it does to represent "T." It takes four times as long to burn four Very lights as it does to burn one. This does not obtain with the Ardois groups. It takes no longer to transmit "N" with five lights than it does to transmit "O" with two, or "interval" with one.

Of these 62 elements, 26 were selected for the letters of the alphabet, 10 for numerals, and to others were given auxiliary and conventional significations.

The letters of the alphabet were grouped together and ran consecutively from A to Z on the keyboard, and the numerals were similarly arranged. The construction of the keyboard is such that all groups representing letters have a red light at the top, and all groups representing numerals begin with a white light. Any other 26 elements might have been taken for letters, and any other 10 for numerals. With an abundant number of elements so that each letter and each numeral may be represented by one alone, without necessity for combinations, code formation becomes very simple. When the transmission of these elements is equal in point of time and convenience, it becomes simpler still. I should be very much obliged to any one who would show me scientifically and logically in what single respect the Ardois alphabet "violates the principles of a good code." Mere assertion is not argument and proves nothing.

But Mr. Niblack may ask me: "If you can take any 26 elements for letters, why not take the 26 in which the red and white lights are grouped in the same manner as the right and left motions in the Myer code? You may object to making any sacrifice for code assimilation, but why not take advantage of any benefits it may carry when such assimilation involves no sacrifice?" And anticipating this question, I will answer it later.

The first sets of Ardois received were installed in the vessels of the Squadron of Evolution in February, 1891. The method of installing the lights has been described. The installation of the keyboard is also a matter of importance. The Chicago's keyboard was mounted in a water-tight box on the after bridge, where the operator could see his own lights and those of the other ships—as important a matter in Ardois signaling as in any other. In the Atlanta and Boston the keyboard was placed in the pilothouse, where the operator had a view of his surroundings somewhat more restricted; and in the Yorktown it was at first placed in the conning tower, where the operator could see very little, but was soon shifted to the bridge above. The success of a signal apparatus, as of that of any other mechanism, depends upon proper installation, proper manipulation and proper care. When Admiral Walker took command of the North Atlantic Squadron I found the Philadelphia's Ardois lights mounted upon the main or after mast, and the keyboard under the poop, at least twenty feet from its break. The operator could not see his own lights, nor those of any other ship. Word had to be passed back and forth by one or more men. Some officers with humorous raillery called it the "Arduous Howling System," and the title was a very telling comment upon the method of installation. The *howling* would have been still more *arduous* if the keyboard had been in the dynamo room. Yet, notwithstanding this unfortunate installation with its attendant disadvantages, Admiral Gherardi did not fail to appreciate the great value of the Ardois, and upon taking command of the Special Service Squadron he at once applied for the apparatus for all his ships. He wrote and telegraphed, and offered to delay his sailing, and five sets were sent to him at Panama.

On the 15th of May, 1891, after the signals had been in use for three months and a half, I made to Admiral Walker a detailed report upon them, which report is on file in the Navy Department. Briefly I stated that the Ardois signal was most satisfactory and valuable as a squadron night-signal, especially for tactical purposes. Some of the keyboards had been found to possess slight mechanical defects which subsequent experience has shown, as I stated at the time, to be easily remedied. I thought at one time that it might be necessary to have platinum contacts, or to have an external switch by means of which the current would be turned on after the contacts were made, and turned off again before they were broken; but I am now satisfied that neither modification is necessary. If the bosses are properly aligned, and the pistons are of good shape, there will be no trouble. The first keyboard supplied the Chicago gave a good deal of trouble. A second, substituted for the first at the New York Yard in the fall of 1891, has worked perfectly since that time. The Bennington's keyboard gave trouble a year ago in the South Atlantic, and the difficulty was entirely remedied by slightly flattening the sphero-conical heads of the contact pistons.

THE SELLNER SYSTEM.—Mr. Niblack quotes from and criticizes my report of last May, upon the relative merits of the Sellner and Ardois systems.

The object and the circumstances of that trial necessarily made my report a comparison between the two apparatuses. I stated that the Sellner signal worked perfectly well; *i. e.*, worked as it was intended to work; and then I criticized favorably and unfavorably its details, comparing them with parallel details of the Ardois, and discussed to the disadvantage of the Sellner their relative scope. The Sellner purchased by the Department had but 24 elements or displays. 30 displays are possible with four pairs of lights; therefore, of the signal which I reported upon, 20 per cent of its scope was thrown away.

I believe the Sellner apparatus which I tested is the one supplied for ordinary use in the Austrian navy. If that is the case, it is evident that its purpose is simply to employ at night the elements of their day flag system. Our Ardois has a much more extended use, representing not only our signal flags, but also a full alphabet and various conventional signals.

Mr. Niblack quotes some of Lieutenant Sellner's replies to my criticisms. I do not agree with him that lenses are not an advantage. There is no question as to the fact that they strengthen the lights in the horizontal plane, and I hold that under unfavorable circumstances—in snow, or haze, or drifting fog—a stronger light increases the value of the signal. Nor do I think that increasing the difficulty of manipulation is in line with what is generally regarded as mechanical progress. I think it tends rather to distract than to secure the attention of the operator. There is no more danger of making a mistake with the Ardois transmitter than with the Sellner, and it is much easier and more rapid of manipulation.

But these are only mechanical questions. The real question is between five lanterns, or pairs of lights, and four. We could have four lanterns if we chose, and keep all the advantages of the Ardois transmitter and the lenses. Mr. Niblack argues vehemently in favor of four, in order that no display shall

exceed four lights, so that the red and white lights of the groups representing letters may all correspond precisely with the 1s and 2s of the Myer alphabet, and so that the red and white lights of the groups representing numerals may all correspond with the Rs and Gs of the Very numerals. This latter code has been forced upon us by the fact that the system possesses only two elements; and it is part of Mr. Niblack's scheme to impose the same combinations for numerals upon the Myer code, at the risk of delay and confusion. Of the Myer and Very systems I will speak later. Of the Ardois, this scheme cuts off all the displays of five lights, 32 in number, and leaves but 30 displays of one, two, three, and four lights. That is, it proposes, solely for the purpose of code assimilation, to diminish by more than 50 per cent the scope of a valuable night signal.

I have stated my opinion that the practical value of code assimilation is small, and that nothing of any importance should be sacrificed to it. Apart from this there are only three considerations to observe in comparing systems of four and five pairs of lights: first, and by far the most important, their practical value; second, their installation; and third, their cost.

It has already been stated that 30 groups of lights or elements is the maximum with four lanterns, while 62 elements are available with five. Of these 62 elements on the Ardois keyboard, 28 are used for the letters from A to Z and the terminations "tion" and "ing." 10 others are used for numerals, and of the 24 remaining, 20 are used for "interval," "final," "danger," "general," "compass," "tactics," "numeral," "cornet," "cipher," "position," "letters," "understand," "interrogatory," "action," "error," "annul," and "keys" Nos. 1, 2, 3, and 4; and four are vacant and may be assigned uses suggested by future demands. I append a copy of the instructions under which the Ardois has been employed in Admiral Walker's command, which explain the employment of the several introductories and conventional signals. These signals, some of which are of great importance, are not employed for any other purpose. 35 compass signals are superposed upon the displays for letters and numerals, and are controlled by the compass introductory. They are not of great value, as courses are now usually given in degrees, a method for doing which is indicated in the appended instructions; but they are sometimes of service and they produce no confusion.

I am strongly of the opinion that certain displays, which demand instant comprehension and prompt action, should have no secondary significations. It is important that they should each be associated in the minds of officers, quartermasters, and signalmen with but one meaning, and that action should be instant and intuitive, unhampered by any needless mental process or avoidable chance of error. Such a signal is "danger." A reference to our day flag signals will illustrate what I wish to convey.

There is a very conspicuous danger flag which resembles no other flag. When this is shown by a vessel it conveys instantly the idea of dangers to navigation and no other idea. If some other flag of ordinary use—say No. 4 or No. 6 of the code—were employed at some particular place—the foretopsail yardarm, for example—to indicate danger, the information would never be so

prompt, certain and imperative, since there would always remain a mental association with the usual uses of the flag.

In the new colors and patterns for signal flags which I have had the honor to submit recently to Admiral Walker, with an argument for their immediate adoption, and which were presented by him to the Navy Department with a favorable endorsement, I took the red flag out of the code and reserved it for use solely as a powder and warning flag.

Several other displays are of equal or almost equal importance to "danger" in squadron cruising, and should have no secondary meanings. "Hard a starboard" and "hard a port," "stop," and "man overboard" are such. It will be observed that in the instructions these meanings are superposed upon displays employed primarily to represent letters and numerals. This I would change. There are four vacant displays now, and one or two others might be vacated without affecting the value of the system.

One display means "cipher," and there are four "keys." These give great scope and variety in the arrangement and use of secret signals, and in the construction of telegraphic codes.

It is this great scope and flexibility, ample for present and future use, that renders five lanterns more valuable than four. The 30 displays of the latter are nearly all absorbed by the alphabet; numerals, introductories, and conventional signals are of necessity doubled upon displays which have at times another meaning. Of course this is feasible, and it may be done satisfactorily. We may let the meaning of the most urgent and important signal depend upon the introductory which controls it, or upon the conditions of its display, and perhaps avoid misunderstanding and accident. If we were limited to four pairs of lights we should get on quite well. The system would be infinitely superior to anything that we had prior to the introduction of the Ardois. But I think I have shown that five pairs of lights are safer, more convenient, and more valuable, and possess an advantage in practical use which it would be foolish to sacrifice to code assimilation.

The installation is simply a question of height of spars, and presents no difficulty. A distance of 12 feet between the lanterns is sufficient, and this with the present Ardois demands 48 feet between the upper and lower lights. The lower light should be above all the boats, davits and ventilators: that is, from 20 to 40 feet above the water-line according to the class of vessel. This places the top lantern from 68 to 88 feet above the water-line, and if the supporting jackstay be hooked to the end of a monkey gaff (which I advocate), that means a height of truck of say 75 to 95 feet. Such spars can readily be carried by any vessel above the class of torpedo catcher. The topmasts of battle-ships, coast-defense ships, and twin-screw cruisers exist only to display signals, and must be fitted to accommodate those which it has been decided to adopt. To say that the Philadelphia's topmasts are too short to properly install five pairs of lights is to reflect upon the equipment of the ship and not upon the signal. One might as well say that the topmasts of the Portsmouth were not long enough to permit the hoisting of her sails.

I propose that torpedo-boats and torpedo catchers shall carry three pairs of lights.

The cost of five pairs of lights will be about 25 per cent greater than that of four pairs. The Sellner four-lantern apparatus costs in Vienna $486.67. The five-lantern Ardois costs in Paris $775.86. The former is of rather inferior workmanship, and probably labor is cheaper in Vienna than in Paris. I give these figures, which do not include freight, simply to indicate their relative cost. Duties I do not take into account, as they go back to the Treasury. The difference in cost is therefore trifling, and there is nothing in either installation or expense which argues with any force against five lights.

THE PRINCIPLES OF CODE CONSTRUCTION.—Much has been said in the essay under discussion about "ideal codes" and the "principles of codes," but no analysis of the subject has been presented, and no rules have been formulated. I propose to begin with a general principle which I should formulate in about the following language:

Given the number and character of the elements in a signal system, the best code is that by means of which a signal can be transmitted with the least expense of time and labor, while sacrificing nothing of precision and accuracy.

This means that the symbols which are the most easily and rapidly displayed should be employed to represent those numerals or letters which are most frequently used. When a single symbol is used to represent each letter or each numeral, and there is no difference in the displays in point of time or convenience, there is no choice, and the assignment may be made at pleasure. I have pointed out that this is the case with the Ardois. It is also true of the assignment of the day flags to numerals. But when letters and numerals are represented by combinations of symbols successively transmitted, as in the wig-wag system, the case is different, and the smallest groups should be employed to represent the most frequently employed characters.

In the wig-wag system of right and left motions or two elements (the third or front motion being employed only as a division point) there are: 2 groups of 1 element each, 4 groups of 2 elements each, 8 groups of 3 elements each, and 16 groups of 4 elements each.

Fourteen letters of the alphabet can be represented by groups of one, two, and three motions; and the remaining 12 must be represented by groups of four motions.

The employment of the letters of the English alphabet in English composition, including small letters and capitals, is in order and proportion as follows:

e 1520	*d* 590	*b* 272
t 1122	*l* 585	*g* 272
i 1035	*u* 509	*v* 205
a 1015	*c* 485	*k* 130
s 895	*m* 395	*j* 100
n 890	*f* 375	*q* 92
o 890	*w* 332	*x* 82
r 783	*p* 317	*z* 57
h 675	*y* 305	*æ* 30

Several of these letters are used in wig-wag signaling as abbreviations of certain words beginning with them, which increases to a slight extent the relative frequency of their employment.

Applying these data, I find that the best wig-wag code would probably be this :—

e, *t*, represented by single motions.

a, *i*, *n*, *r*, represented by groups of two motions.

c, *d*, *h*, *l*, *o*, *s*, *u*, *w*, represented by groups of three motions.

b, *f*, *g*, *j*, *k*, *m*, *p*, *q*, *v*, *x*, *y*, *z*, &, represented by groups of four motions.

Although *r* is ranked in alphabetical frequency by *o* and *s*, it is employed in abbreviating *are* and *your*. Similarly *w*, although ranked by *f* and *m*, is employed in two abbreviations.

The Myer and Continental Morse codes are as follows: The American Morse I leave out of consideration ; it is clumsy and unreliable and has no advocates as a wig-wag code.

Myer Code.

i, *t*, represented by single motions.

a, *e*, *n*, *o*, represented by groups of two motions.

c, *d*, *h*, *l*, *r*, *s*, *u*, *y*, represented by groups of three motions.

b, *f*, *g*, *j*, *k*, *m*, *p*, *q*, *v*, *w*, *x*, *z*, &, represented by groups of four motions.

Continental Morse Code.

e, *t*, represented by single motions.

a, *i*, *m*, *n*, represented by groups of two motions.

d, *g*, *k*, *o*, *r*, *s*, *u*, *w*, represented by groups of three motions.

b, *c*, *f*, *h*, *j*, *l*, *p*, *q*, *v*, *x*, *y*, *z*, represented by groups of four motions.

The Myer is by far the better of these two, showing indeed but one serious discrepancy, viz., the use of two motions to indicate *e*. The Continental Morse is poor : *g*, *m* and *k* are all clearly out of place, being used with relative infrequency, and, conversely, groups of four motions are improperly assigned to *c*, *h*, and *l*.

I have before me a report of Ensign Lloyd H. Chandler, of the U. S. S. Concord, into whose hands the trial of the "Modified Myer Code," lately sent out by the Navy Department, was placed by Commander White. Mr. Chandler went into his subject carefully, and discussed the results in a most satisfactory manner. He took a number of signals aggregating 853 words, and tabulated the actual number of flag motions required to send these 853 words, excluding "end of words," and taking no account of abbreviations. The result was as follows :—

Myer Code,	9035	flag motions.
Continental Morse Code,	9298	" "
American Morse Code,	9013	" "

The American Morse was 22 less than the Myer. This is accounted for by the fact that in the American Morse code there are three letters, *e*, *l* and *t*, made by *one* flag motion, and that the three letters made by five motions, *p*, *y* and *z*,

are not of frequent use. If in the Myer code the sole change were made of representing *e* by one motion, and *i* by two, there would be saved in the above case 37 motions, and the Myer code motions would be reduced to 8998.

Mr. Chandler then proposed a code by which the same 853 words could be sent by 8781 flag motions. This code only requires the exchanging of *e* with *r* and of *w* with *y* to correspond exactly with the code which I have deduced above from known data; and, as I have already observed, Mr. Chandler took no account of abbreviations, while I have determined the relative positions of three of these same letters by their employment in abbreviation.

Mr. Chandler further took 600 words from a newspaper paragraph, and tabulating them as before, found that to transmit them required by the

Myer Code,	6926	flag motions.
Continental Morse Code,	7073	" "
American Morse Code,	7075	" "
Proposed Code,	6780	" "

The Myer code is in this case ahead of the Morse, and the proposed code is far superior to either.

To represent numerals by a wig-wag code there are two logical methods. The first is to introduce and end the numerals by a conventional flag motion or group of motions, meaning "numerals follow" or "numerals are finished," and then to employ the simplest combinations of the code, viz., the two of one motion, the four of two motions, and four of three motions for the ten numerals. The second is to employ groups of elements which are not used for letters. This requires us to take groups of five flag motions, and obviates the necessity of an introductory and closing signal. I much prefer the latter as less liable to error. The groups of four, proposed by Mr. Niblack, and recently sent out for trial as part of the "Modified Myer Code," are neither one thing nor the other, and are not logically defensible. Apart from the liability to error which results from duplicating, it takes far more flag motions to transmit numerals than it would if groups of five were employed, since each time numerals are signaled they must be introduced and finished by "num." requiring 10 flag motions. Here we are asked by Mr. Niblack to make a substantial sacrifice in time and certainty, simply that the numerals of the Myer may correspond with those of the Very, two systems absolutely dissimilar in their functions and scope, and in the manner of their use. We are obliged to use groups of four in the Very's signals because bracketing has proved unreliable, and time intervals cannot enter. If we had a third element, say a double star fired from the same cartridge and separating upon explosion, we should go at once to groups of three; and if we had two more elements, we should go to groups of two. Each system of signals should be free to develop and improve within its capacity and the limitations of its use.

To return for a moment to the Ardois. I will now state why the Myer groups representing letters should not be paralleled by the displays of the Ardois.

It would interfere with an arrangement of the keyboard which I think we shall find desirable in the future. It has been the experience abroad, and will

probably be ours, that torpedo-boats can carry only three pairs of lights. This limits them to 14 displays, and to a tactical code. These 14 displays should be given the same meanings on the large keyboard that they bear on the small one, in order that torpedo-boats may communicate with larger vessels as well as with each other.

SHAPES FOR DISTANT SIGNALING.—Experience does not seem to have gone very far in this direction. Shapes to be visible at great distances should be large, and therefore strong and heavy. I think there would be an advantage in employing not less than four—say a globe, cylinder, cone, and inverted cone—in which case there would be 16 groups of two elements; abundant material for a numeral code in groups of two, independent of time intervals and division signals. But this is merely a suggestion.

For squadron signaling at ordinary distances I think flags will always be found preferable—more rapid and less expensive in wear and tear.

CONCLUSIONS.—To recapitulate: In any signal system the determination of the number and character of the elements and the method of their transmission is the primary requisite. As a general rule, it diminishes the labor and shortens the time of signaling, and increases the scope and value of the system, to increase the number of elements; but this should never reach a point which produces confusion; *i. e.*, precision and certainty should never be sacrificed.

The code should then be so constructed as to render the time and labor of signaling as small as possible.

Each system of signals, day or night, squadron or distant, should be that which is best suited to the purposes and conditions of its use; and should be free to develop and improve by the suggestions of experience and the assistance of inventive talent.

Code assimilation is entirely an external bond—an aid to memory—which can only be imposed upon naval signaling to the detriment of essential considerations. No existing system is really complicated. An intelligent apprentice can be taught the rudiments of all of them in a week, and, after that, practice is all that he needs.

Referring to different portions of this paper, I find the following systems, in the light of present knowledge on the subject, entirely suited to naval needs:

Distant Night Signaling.—The Very red and green lights as they now exist, with the groups of four which have been some time in use.

Squadron Night Signaling.—The Ardois in its present shape, subject to change of keyboard if it should be decided to equip torpedo-boats with three pairs of lights. This change of keyboard would require only a change of bosses and of the upper plate.

Day Flag Signaling.—New flags with better patterns and better colors, plates of which have recently been submitted to the Navy Department; and whenever the Department is ready to take up the revision of the Signal Books, an increased number of flags which will permit a better code.

Wig-wag Signaling.—The three elements of right, left, and front, or 1, 2, and 3, and the following code:—

Letters.

a	22	*h*	122	*o*	211	*v*	1222
b	2112	*i*	12	*p*	1212	*w*	111
c	121	*j*	1122	*q*	1211	*x*	2122
d	222	*k*	2121	*r*	21	*y*	1121
e	1	*l*	221	*s*	212	*z*	2222
f	2221	*m*	1221	*t*	2	*&*	1111
g	2211	*n*	11	*u*	112	*tion*	2111
						ing	1112

Numerals.

1	12222	6	22211
2	21111	7	11112
3	11222	8	22221
4	22111	9	11111
5	11122	0	22222

And substantially the abbreviations heretofore used, and such conventional signals as may be deemed necessary.

In distant signaling by shapes the field is open.

I find no more "chaos" or confusion in these several systems with different codes than I do in checking the recoil of a rifle against the shoulder of a man, of a howitzer by a compression slide, and of an eight-inch gun by a hydraulic piston. Each is carefully suited to its uses, is the best product of our present knowledge and experience, and is free to develop upon its own lines.

The revision of our signal books is a pressing need. Upon the direction which this revision takes will depend the character of our day flag system and its code. The work cannot be properly done in an office of the Department, nor is it likely to be done in a squadron, where other demands are always pressing. My belief is that it would be best accomplished by placing it in the hands of a board, and giving that board authority to go to sea at different stages of its work with two ships of the North Atlantic Squadron, to test by exhaustive trial the merits and demerits of its propositions. The work finally concluded, the board should be ordered to report to the Commander-in-chief of the North Atlantic Squadron, and all the tactical and military features of the proposed system should be tested, employing for the purpose as many new ships as could be assembled.

U. S. S. CHICAGO,
FLAGSHIP, SQUADRON OF EVOLUTION,
AT SEA { Lat. 24° 34 North.
{ Long. 81° 16 West.

ORDER NO. 10. *January* 29, 1891.

The following Instructions for using the Ardois Signal System are hereby established for service in this Squadron.

J. G. WALKER, *Rear Admiral, U. S. N.*,
Commanding Squadron of Evolution.

The code to be employed will be indicated by the introductory display, as follows:

If "compass" be displayed, the display that follows it will have the signification of the lower line, and will indicate a course to be steered. Sectors 37, 38 and 39 apply quarter or half point corrections to a course previously signaled, or to the one that the Squadron is steering at the time.

"Danger," not followed by a second signal, means danger ahead, and is an emergency warning signal. If the danger is not ahead, "danger" will be followed by a second display, which will be read as if preceded by "compass," and will indicate the bearing of the danger.

"Ahead" in this sense means the direction in which the Squadron is steering.

"Tactics" means that the signal following will be found in the Fleet Drill Book; and "Gen." that it will be found in the General Signal Book. In both cases the signals following are the numerals in the upper line from zero to nine inclusive—sectors 32 to 41; the numeral, sector 48; and the interrogatory, sector 54.

The telegraphic and geographic dictionaries will not be employed, as the spelling of the words is equally rapid and more certain.

"Cipher" will indicate the employment of any prearranged secret code.

"Letters" indicate the employment of the upper line, both letters and figures. In this code "interval" indicates the end of a word. Following the introductory display "letters," numbers, expressed in Arabic notation, are not to be preceded by "numeral," sector 48; but in using the General or Tactical codes, the display "numeral" has the same employment as the numeral pennant in day signaling.

The following displays are made independently without code distinction:

"Yes" and "no," sectors 40 and 41. Care must be taken not to employ these sectors with these meanings in the body of a message, or at any time when controlled by the introductory display of "Gen." "Tactics" or "letters."

"Position" has the same use as the position pennant in the daytime.

"Cornet" is used as a call when the signal is intended for one or more ships only. It may be followed by the ship's number, using the numerals, sectors 32 to 41, or by a designating letter, where such has been assigned.

"Understand" is employed as an answer to "danger," and will be employed in other cases, where a repetition of the display might cause confusion or uncertainty. Its use in each case will be prescribed.

The answer to a display will, except in the special instances where "understand" is employed, be the repetition of that display; and this answer will be made for each display, whatever the code used. The sending ship will keep the lights on until the receiving ships have all shown the same display. This has a double advantage—that of repeating back the signal received, and that of enabling a ship of the Squadron, to which one or more of the Flagship's lights are masked, to take the signal from a repeating—*i. e.* answering—vessel.

The display should be understood by the receiving vessel before it is repeated. If not understood, the "interrogatory" will be displayed.

"Error" indicates that the sending vessel has made a mistake in the last display, and annuls that display.

"Annul" annuls the whole signal back to and including the introductory or call. If the sender wishes to annul only a part of the message, he follows "annul" with a number, made by using the numerals, sectors 32 to 41; and this indicates the number of displays, immediately preceding the display "annul," which are to be annulled.

"Final" completes all general, tactical, and aphabetical signals; but it does not follow compass signals, the "danger" signal, or single displays complete in themselves.

"Action" is the signal of execution for all compass signals, tactical signals, and exercise signals.

"Keys" Nos. 1, 2, 3, and 4, and the blank sectors 43, 44, 45, and 58, are not at present assigned any signification.

Examples: Flagship wishes to signal "send a boat" to Squadron. She displays "Gen." All repeat. She displays sectors 33, 32, 40, 39, in succession, holding the lights on in each display till all the ships have repeated. She then makes "final" and this ends the message. "Action" is not needed here.

Flagship wishes a boat from Yorktown. She displays "cornet," all vessels repeat. She then displays Y, sector 37 (or Yorktown's number if there be no designating letter). Yorktown alone repeats. Flagship then makes "Gen," and goes on as before.

To signal Squadron to steer S. W. ½ S., the Flagship displays "compass." All ships repeat. She then displays sector 22 (S. W. by S.). All repeat. Then sector 38 (½ St'b). All repeat. She then displays "action." All repeat. When "action" is turned off, the Squadron steers the new course.

All courses are magnetic.

To signal courses in degrees, display "compass," then North or South, then in numerals, the number of degrees to the right. For example, to signal N. 30° W.: make "compass," "South," "1," "5," "0," "action."

[Note.—It will be observed that the uses of the numerals in this case, after "annul," and after "cornet," (to make a ship's number), are special, and are not preceded by the regular introductories.]

The following displays, when made independently—*i. e.* not preceded by an introductory, indicate:

Sector 29 The ship showing it will pass through the formation (as for example to gain or regain position). Each ship makes "understand" and guards against collision.

Sector 28 Man overboard from vessel displaying it. Each ship answers by "understand."

Sector 37 Helm hard a starboard.

Sector 6 Helm hard a port.

[Note.—The above two signals are of immediate execution to avoid danger, and are not followed by "action." As soon as they are executed, a compass course should be signaled on which the Squadron will be steadied.]

Sector 25 Stop.

Lieutenant J. B. MURDOCK, U. S. Navy.—While cordially agreeing with the views advanced by Lieut. Niblack, I wish to specially emphasize what appears to me to be the vital point, viz. the necessity of clearing up the muddle into which we have fallen, and the establishment of a simple yet flexible code which will be applicable to all conditions of day and night signaling. Twenty years ago we possessed a simple system, but by the abolition of the Myer code and the substitution of two others successively, and the introduction of the Ardois, we have reached a stage where, as already stated in the discussion, the easiest solution is to "send a boat."

We should have one easily memorized code applicable to all conditions. In choosing this code the simpler it is the better. The plan outlined by Comdr. Chester offers many advantages on account of the large number of signals possible in a three-flag hoist, and if fully developed might be an improvement over any as yet tried. I should recommend the substitution of a flashing white light for the green called for. This plan requires, however, a complete new signal book, and seems to be somewhat outside the limits of the present discussion. As Lieut. Niblack is recommending a simplification of present methods and a return to old and well-tried codes, I heartily concur with him.

Mr. Niblack puts the question in its true light when he says "that it should not be lost sight of that a good code is of the first importance, and the mechanical means of transmitting it is in a sense secondary." So far as electrical signals are concerned, the first point to be considered is the code. That decided upon, the means for transmission can be settled. The only influence the latter should have on the decision is that no code should be adopted which involves complex or objectionable transmission. Our course of action with the Ardois has been exactly the reverse. We chose the transmission, and bought the code with it.

My objections to the Ardois are:

1. It introduces an entirely arbitrary code, too complex to be memorized, and necessitating a complete revision of our signal book, to obtain any advantage from its use.

2. It employs five double lanterns, requiring at least fifty feet hoist. This cannot be obtained on very many of our ships. An attempt was made to install an Ardois set aboard the Miantonomoh, and no place could be found to put the lanterns except on the forestay. The lights were then only six feet apart vertically, and could not be seen from aft. The arrangement was so ridiculous that the lanterns were taken out.

3. The French Ardois set as originally chosen is, in my opinion, mechanically and electrically the worst signal box in use. The objectionable points are:

a. The box is large and clumsy.

b. It is not water-tight.

c. Spring contacts are made by pins against bosses on the rings inside the box. These contacts are bad, and as the bosses deteriorate rapidly, they have to be constantly repaired. Repairs are, moreover, difficult to make.

d. The spark on breaking circuit takes place on the bosses, causing the deterioration referred to.

c. The lettering of the dial is so arranged that one-half of the signals are upside down to the operator.

The above defects will be overcome in some sets now under construction. Many other changes have been made in the lanterns and other features.

I think that no better solution of our night signal question can be adopted than that proposed by Lieut. Niblack. The first question, that of the code, he decides in favor of the Myer, as being one that has been well tried and found to be thoroughly good. The code settled upon, we find that it can be represented by four double lanterns. Next arise the minor and comparatively trifling matters of mechanical detail, construction, etc., most of which have already been settled by the Bureau of Equipment.

In matters of detail there are one or two things that still admit of discussion or experimentation. Experiments at the New York Navy Yard do not indicate that there is any advantage in a focusing lantern. If the loop of the lamp filament is one-eighth of an inch out of focus, there is very much less light given off in a horizontal plane than when an ordinary lamp is used. For this reason the Germans and Austrians discard lenses entirely, using an opal shade on the white lantern and a colored one on the red. It is claimed that the opal covered light is visible a greater distance than similar lanterns would be with clear glass. It would be interesting to have a practical test of the use of the white lights in each lantern, making one fixed and the other flashing. It is doubtful, however, if anything would be gained, as the present lights are visible up to the point where their distance apart causes them to blend, and nothing would be gained in increasing candle power, unless greater intervals can be given as well.

The double lantern, half red and half white, placed on the truck and worked by a key under the Myer code, seems preferable to a single lantern worked on the Morse system, as is common in several European navies. A message signaled by flashes can be read with less liability to error than if transmitted under the intervals necessary in the Morse code.

In search light signaling, also, the Myer code, signaling by short flashes, for the same reason seems preferable to the Morse. Experience gained ashore indicates that even in the clearest weather the search light beam is visible at a great distance, if projected so as to appear high above the observer's head. At sea, the air containing more vapor and clouds and less solid matter, the beam might not be so apparent. The search light cannot be considered as a part of the regular signal system, although its use will, under certain circumstances, greatly increase the distance at which communication is possible.

The Ardois system has been tried for some time in the Squadron of Evolution, and is understood to have worked well. From all that I can gather from officers who have been shipmates with it, its good points are those which are inherent in any decent system of electrical night signals; its defects are its own. Any modification proposed should retain the former and eliminate the latter. The one advantage it possesses over a four-lantern code is that, having 62 combinations, it admits of more rapid signaling than the four-lantern hoist, which has only 30. By a complete revision of the signal book, dividing all

signals under 62 heads, each having 62 subdivisions, it is possible to obtain 3844 one or two display signals. It is opening another serious question when we suggest a new signal book, and the advantage stated is otherwise unobtainable. All signaling in the Squadron of Evolution has been done, I am informed, by using the letters of the code for spelling, and the numbers for the general signal book. Thus used, the apparatus necessitates just as many displays as a four-lantern code would, and all necessity for the fifth lantern is removed.

It may be suggested that a possibility of error is involved in having a signal mean both a letter and a number. This seems improbable, as the first display would indicate the code, whether spelling or general. If spelling a message under the Myer code, numerals introduced into the message would be preceded by "numerals" and followed by "letters," when the spelling was renewed. This involves two extra displays, but, on the other hand, greater rapidity of signaling would be possible from the smaller size of the board and the simpler code.

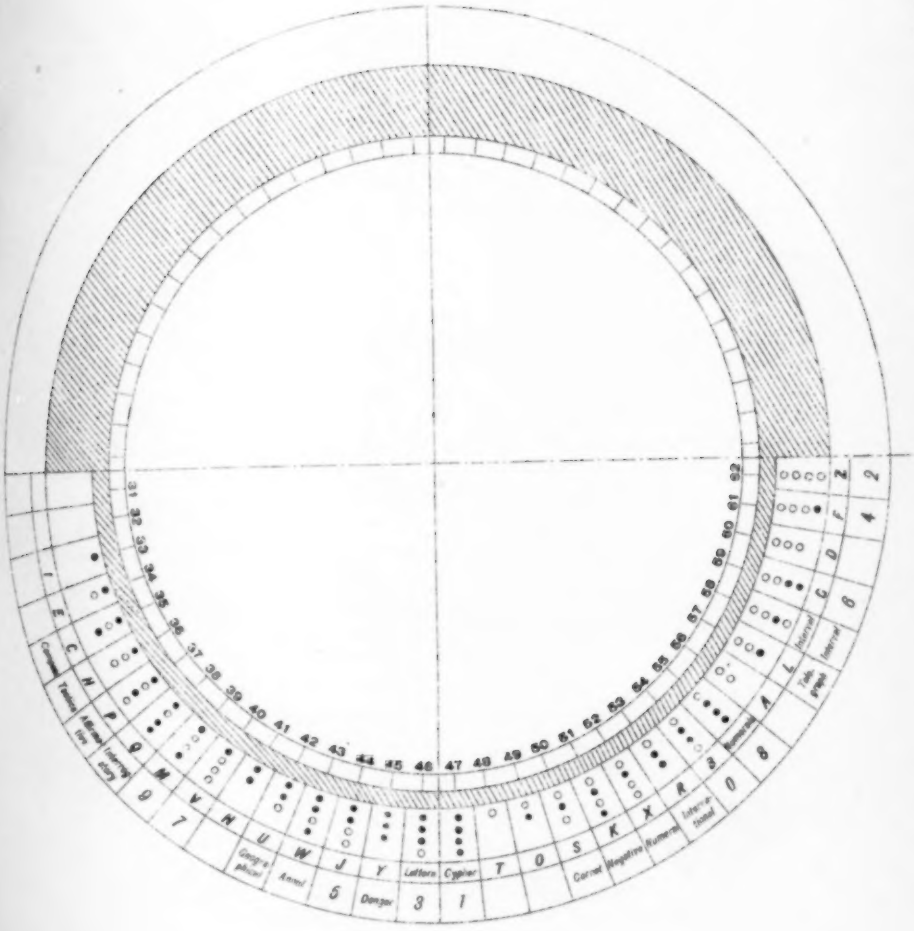
I understand that it is claimed by officers favoring the Ardois code, that as masts are now intended mainly for signaling purposes, they should be made tall enough to carry whatever number of flags or lanterns may be necessary. I heartily concur in this, but with addition of the words "and no taller." If we can with four lanterns transmit signals with the same accuracy and rapidity as with five, it is certainly inadvisable to add a lot of additional tophamper, merely to carry the extra lantern. In considering the space available, moreover, it should be borne in mind that the lanterns should all be below the military top, on account of interfering with the fire of the machine guns.

As the Miantonomoh could not well carry five lanterns, so the Vesuvius and Cushing may find difficulty with four. The latter, spaced ten feet apart, require about thirty-five feet. For signaling up to a distance of two miles it will probably be sufficient to make the spaces six feet, or a total hoist of twenty-one feet. For signaling at greater distances the upper lantern could, by a simple attachment to the signal box, be arranged so as to signal by the Myer or Very code with red and white flashes, and these signals could probably be read four miles. As under the proposed code any signal can be readily transmitted by one double lantern, it appears to me to be wiser to install only one in torpedo-boats, to save weight and complexity. A torpedo-boat could then easily exchange signals with any vessel having the four-light hoist. It is at once evident that the Myer code is much better adapted for this system than either the Morse or Ardois.

The code calls on page 488 are too complicated for night signaling. A single letter necessitating only one display will do as well, thus:

H. Use fleet drill signals.
U. Use geographical signals.
R. Use international signals.
C. Use compass signals.
L. Use telegraph signals.
Letters. Use letters.

All but the latter are three-lantern displays.


31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62
Comma
Tirets
Alinéa (retour)
Interligne (espace)
Guerre & police
Amour
Danger
Lettres
Chiffres
Carrés
Négatifs
Numéros
Intervalle (blanc)
Numéraux
Tab. prépa
Intervalle
Intervalle

Vessels' numbers could be transmitted under the rules of the Very code.

The first display of a message would designate the code, the second might be a distinguishing letter for a vessel (the above code letters being avoided), or "interval," if the signal is general. The third display would commence the message proper. All signals not specially designated otherwise are general code.

It is impossible to assign a signal for each compass point with the thirty possible combinations. Two methods of compass signaling are possible. One is to designate the cardinal points by their initial letters, N., E., S., and W., in the Myer code, and to signal others by these initials—thus, N. E. N. would signify N. E. by N. Another method would be to mark 28 of the segments with compass points, the cardinal points being designated as above, and the quadrantal points, N. E., S. E., S. W., and N. W. being made by signaling each letter separately.

The criticisms made by Lieutenant Staunton on the Sellner apparatus tested on board the Chicago seem to arise from an impression that the apparatus must be taken as a whole or rejected. This is contrary to our practice thus far in electrical apparatus, the universal custom of the Bureau of Equipment having been to select whatever good features came to its notice and to incorporate them in specifications drawn up to give the service what it needs. No greater mistake can be made than to go into the market and purchase what any inventor thinks will exactly fill service necessities, and yet this is just what has been done with the Ardois "system." The more satisfactory plan is to encourage invention to fill specifications and requirements outlined by officers thoroughly cognizant of the nature of the apparatus needed. If the Myer code can be authorized by the Department, the construction of a signal set conforming thereto is a simple mechanical problem.

A special requirement of night signaling, where each flag of a hoist requires a separate display, is that all important emergency signals should be one, two, or three flag hoists. This will lead to a great saving of time.

The signal sets now in use in the service can be adapted to the Myer code by disconnecting the upper lantern and fitting a new face-plate, as shown in the appended figure. New ones could probably be made semicircular, and of about one-third the size of those in service.

Lieutenant A. P. NIBLACK, U. S. Navy.—It is very gratifying to have stirred up so much discussion on such an important subject. I have felt that my idea of one code for all purposes was too good to be true; and, if true, too simple to be acceptable. I am now, however, convinced that I have practically the service with me on this subject, and I am glad to say there is some prospect of speedy action being taken by the Navy Department.

My own criticism of my own article on Naval Signaling is that I buried two or three simple propositions under a mass of data about codes and methods in our own and foreign services. I did this trying to be thorough and trying to do justice to all sides. My critics, seeing the situation more clearly and dispassionately, have placed certain issues in new lights. As

Lieutenants Mulligan, Fullam, Bowyer, Mason, and Knapp, and Captain Philip practically side with me on the main issue, I can only express my gratification and pass on with the comment that the New York with truck double lanterns for signaling marks a new era. The millennium will come when we get four lanterns in the Ardois. As Lieutenant Huse rather favors the retention of the American Morse code, I can only beg him to repent while there is yet time. I accept Lieutenant Chambers' modification of my scheme of shapes as a clever and happy solution of the evils resulting from refraction in distorting them at long distances. As to fog-whistle signaling, his method may be better than that in the General Signal Book. In view of his experience, no decision should be made without further trial. Commander Chester very gratifyingly explains briefly and lucidly the scheme of Commander Davis, now awaiting the action of the Chief of the Bureau of Navigation.

Lieutenant Staunton brings out most happily all there is in the real opposition to the adoption of the modified Myer code. Starting from fundamental principles he evolves a new code (practically a modified Myer) which conforms to and confirms the principles I enumerate on page 445. I do not disapprove of the Ardois code simply because it happens to run foul of what I propose as the four-element modified Myer. On page 451 (bottom) I point out that the numeral characters of the Ardois were 1, WR; 2, WRW; 3, WRWR; 5, WRWRR, etc.; and 0, W. This clearly violates Rule 6 on page 445, and Lieutenant Staunton in his new code is careful to have characters for numerals contain the same number of elements. When I say, therefore, that the Ardois numeral code violates *one* of the principles of signaling, I am not unreasonable. As to its violating *all* the principles, I ask Lieutenant Staunton to take the table which he gives of the employment of the English alphabet in English composition in order and proportion, and carefully compare it letter by letter with his Ardois alphabet, and see how the latter ignores every consideration so painfully and elaborately set forth in his own table. I dealt the Ardois alphabet no such blow as this. I simply said, "This code is unfit for any other purpose," which at least allowed the inference that it works well with five lanterns. When its own author gives it the black eye, I can only express my amazement that he does not offer to substitute his theoretically perfect code for this self-condemning Ardois code, thus demonstrating that he is not willing to allow his aversion for assimilation and harmony to go to the extreme of burdening us with an unnecessary code. Fact is, the sentiment of the service is against five lanterns and in favor of four. This is not a rash statement. A five-lantern machine was bought and a code was invented to go with it. Those who were instrumental in getting it of course stand by it. It is out of date in Europe, and we are losing time, money, and dignity in holding on to five lanterns. If we come down to four lanterns, we of course cut off certain special displays, such as "danger," "hard-a-starboard," "stop," "key No. 1," etc. On this point Lieutenant Staunton makes his final stand, saying "I am strongly of the opinion that certain displays, which demand instant comprehension and prompt action, should have no secondary significations. It is important that they should each be associ-

ated in the minds of officers, quartermasters, and signalmen, with but one meaning, and that action should be instant and intuitive, unhampered by any needless mental process or avoidable chance of error. Such a signal is 'danger,' . . . . 'hard-a-starboard,' 'stop,' and 'man overboard.'" Now Lieutenant Staunton spent half the midwatch on the bridge to such good purpose in finding out the worthlessness of the army torch at sea, that, notwithstanding that he returned to his berth chilled, disgusted, and smelling of turpentine, I ask him to persevere in his researches. As a watch-officer I enter my solemn protest against gambling my commission on a signal to vessels astern such as "stop," "danger," "hard-a-starboard," by means of an apparatus with 62 keys, played on by a signal boy at possibly the other end of the ship, when the law of Congress authorizes helm signals with the steam whistle, when we have five speed lights now for no other earthly purpose than to show "stop" or emergency, and when "man overboard" is a Very signal. If we can knock this evil principle on the head by removing one lantern in five, let us continue the good work and come down to three lanterns and do away with speed signals altogether! That "key No. 1" business is the mystery before which we are to bow! *We have no cypher codes*, but with four lanterns it is just as feasible to provide for the future as with five lanterns. As for marring the keyboard or transmitter, the Office of Electric Lighting have a scheme by which, in an hour, they can convert a five-lantern machine into a four, by removing the *top* lantern and use thirty adjoining sectors on the present form of transmitter. It involves no expense, and we are as surely coming to it as that we have arrived at the conclusion that the Ardois code violates the fundamental principles of signaling. Lieutenant Staunton's paper is certainly a most able and valuable one. His arguments against the four-lantern scheme are practically those recently used by the Commander-in-Chief of the North Atlantic Station in a letter of protest to the Secretary of the Navy against any change in the Ardois. The opposition to change rests on broad shoulders, and the two people who are fighting it need no odds in any encounter. I believe, nevertheless, that when the returns come in from the service at large as to the modified Myer code, that it will be elected by a landslide. I have appeared to be trying this signal fight single-handed, but I have felt all along back of me the more or less active approval and sympathy of, not those in high rank, but of the quiet thinkers who leave the rushing into print to younger men like myself, whose enthusiasm for reform has not been as yet chilled by a mature cynicism, and whose impatience with things as they are is only justified by an earnest desire to shoulder the hard work incidental to such proposed reforms.

I thank my critics. I thank the service at large for its patience and long-suffering. I regret not seeing Lieutenant Murdock's paper in time for comment.

PROFESSIONAL NOTES.

REPORT ON THE TEST OF A 14-INCH NICKEL STEEL HARVEYED ARMOR PLATE.

By Ensign R. B. Dashiell, U. S. N., *Inspector of Ordnance, in Charge of the Naval Proving Ground.*

[Published by permission of the Bureau of Ordnance.]

Naval Proving Ground,
Indian Head, Md., *February* 13, 1893.

The Chief of the Bureau of Ordnance, Navy Department.

Sir:—I have the honor to submit the following report of the test of a nickel steel Harveyed plate. The firing took place on the 11th instant in the presence of the Chief of the Bureau. The gun used was 10-inch B. L. R. No. 10. The projectiles were all Holtzer armor-piercing shell, weighing 500 pounds each. The weather was fair, the temperature being about 42°-45° F. The plate was secured by 16 bolts of the 2.8″ pattern to an oak backing 8′ high by 10′ wide. The bottom of the plate rested on a string-piece of oak, which in turn was supported by a solid foundation of heavy oak timbers 2′ deep in the ground, and extending more than the full length of the plate. This backing was held against the oak backing already in place on the target structure by 13 iron bolts 1⅜″ diameter, a space of 1′ being left between the two backings for access to the nuts of the armor bolts. The backings were kept apart by 16 cubes of oak 12″ on edge, with the grain running in the direction of the line of fire. The standard rubber washers and cups were used on the ends of the armor bolts under the nuts, and all nuts were set up as hard as possible. The entire installation of the plate was as solid and substantial as could be desired. The distance from the muzzle of the gun to the face of the plate was 385 feet, and the face of the plate was normal to the line of fire when directed at its center.

Round 1.—Striking velocity, 1472 f-s. Projectile, Holtzer A. P. shell No. 10. The point of impact was 38″ from the right edge and 32″ from the bottom of the plate. The projectile smashed on the face of the plate, the point and a small portion of the ogival remaining welded in the impact. The rest of the projectile broke up into small fragments, which flew to the sides and rear several hundred feet. Much of the projectile was delivered radially as mitraille over the surface of the plate. These pieces cut off almost the whole of the front and exposed edge of the timber upon which the plate rested. The estimated penetration, judgment being based upon experiences with other Harvey plates in the past, was about 2″. The plate, even in the immediate neighborhood of the point of impact, was quite cool, while the pieces of the shell were very hot. The plate was not cracked, neither was the backing nor structure disturbed by this round. The largest fragment of shell recovered weighed 25 pounds. The face of the plate was not dished at all. . . .

Round 2.—Striking velocity, 1859 f-s. Projectile, Holtzer A. P. shell No. 9. The point of impact was 35″ from the left edge and 33″ from the top of the

plate. The shell broke up, leaving a part of its head welded into the plate. The surface of the plate was somewhat scaled off to a depth of from ¼″ to ½″ in a rough circle around the impact. A through crack was opened, extending from this shot-hole downward to the left, running to the edge of the plate. On the edge of the plate this crack was opened about 5″. A fine crack, of depth unknown, extended from this shot-hole to the right and downwards, running tangent to the impact of Round 1, and losing itself about 12″ below the latter impact. The structure set back elastically about 1″. The plate was warm close to the shot-hole and the fragments of shell were very hot. The estimated penetration was 5″. The surface of plate was dished about 1″. The largest fragment of shell recovered weighed 63 pounds. . . .

ROUND 3.—Striking velocity, 1959 f-s. Projectile, Holtzer A. P. shell No. 12. The shell struck the plate 34″ from the right-hand edge and 25″ from the top, breaking up, the fragments flying in all directions. Its head, very much upset, remained welded into the plate. The impact showed the same circular scaling as that of Round 2. A through crack .5″ to .7″ wide was opened to the top of the plate. A through crack extended downwards and to the left until it met almost normally the crack between the impacts of Rounds 2 and 1. A fine crack, half way through the plate, extended from impact No. 3 slightly downwards to the right edge of the plate. The crack between impacts Nos. 2 and 1 was widened to ½″ diameter, and was extended to the bottom of the plate. The crack from impact No. 2 to the left edge was widened to about .7″. A fine crack half-way through the plate appeared from impact No. 2, extending vertically upwards to the upper edge. Thin fragments of metal were scaled off the edges of all the wide cracks. The estimated penetration was about 6″. The backing and structure set back about 2″ and recovered 1″. The left vertical timber was split off from the shock, the split passing through the line of bolt-holes. All bolts and fastenings remained intact. The largest fragment of projectile recovered was the base, which was almost entire and, roughly, about 5″ in length, weighing 127 pounds. . . . . The plate up to the third round had been an entire mass, resisting with its full weight each one of the three shots. After the third round it was divided into three almost equal fragments. The fourth round was directed at the center of the lower left-hand fragment.

ROUND 4.—Striking velocity, 2059 f-s. Projectile, Holtzer A. P. shell No. 4. The shot struck the plate 23″ from the bottom and 26″ from the left edge, broke up, the head remaining welded into the right-hand portion of the impact, the base and body breaking into small pieces, the largest weighing 75 pounds. The estimated penetration was from 10″ to 11″. Cracks already in the plate were widened out considerably, and the plate was broken into seven fragments, all of which remained on the backing, no bolts having been broken. The piece of plate which received the blow of the projectile was broken into three fragments. Its surface was scaled off considerably around the point of impact. The two left-hand pieces of the piece above and to the left, that is, the upper left-hand corner of the plate, were thrown off to the left, both upwards and downwards; the right-hand and larger piece was slightly displaced to the right and upwards at its right-hand end; the remaining two-thirds of the plate was apparently intact and in its original place on the backing. The backing itself was uninjured except that the great force of the blow actually compressed the timber immediately beneath the piece of plate struck, the compression showing about 1″ at the left hand and only visible part of the backing thus affected. The structure set back bodily about 6″, all the steel channel irons buckled badly, but the wood filling timbers placed side by side with these channel irons gave their full support to the blow. . . .

Regarding the entire plate as the target for the reception of the first three shots, and the lower left-hand fragment as the target for the fourth shot, the following table of data is appended:

	Total Energy.	Energy per Ton of Plate.	Estimated Penetration.
Round 1.	7520.9 ft. tons.	470.5 ft. tons.	2″
" 2.	11995 "	749.7 "	5″
" 3.	13320 "	832.5 "	6″
" 4.	14715 "	3344.3 "	10 to 11″
Total,	47550.9 ft. tons.		

Weight of fragment attacked, 4.4 tons.

The marked difference in the performances of Round 1 and Rounds 2, 3 and 4, and the close resemblance between the last three, would seem to indicate that these differences were due to another cause than the increased velocities alone with which these last shots were fired.

The point of the first shell unquestionably did not penetrate as far as the interior limit of the Harvey hardening. Its effect was confined almost entirely to the hard face of the plate, and nearly all the energy of impact was absorbed in shattering and heating the projectile. The plate close to the point struck was *cold*, while all pieces of projectile were very hot. There were no cracks in the plate, showing an absence of, or a perfect resistance to, wedging effect; and the structure was not disturbed or shaken in any way.

As soon, however, as the velocities were increased to such an extent as to warrant the belief that the point of the projectile got in beyond the interior limit of the hardening, all the impacts, even with differing velocities, show the same general characteristics. A greater per cent. of the energy is absorbed by the plate and structure than in the first round. More of the projectile remained welded into the plate, and the wedging effect of greater penetration became noticeable. The fragments of projectile recovered were larger in size than with the first shot. It is impossible to measure the penetration of the first three rounds. A break in the plate allows a rough estimate to be made of the penetration of the last round. The estimated penetrations are based entirely on opinions formed from my experiences with other Harveyed plates from which the projectiles have been removed, and are by no means absolute.

In forming a correct estimate of the remarkable qualities of this plate it is necessary to consider the results of the test from what might be termed its external and internal aspects—external as regards plate and projectile, internal as regards the ship or structure supporting and protected by the plate.

Considered externally, the plate fulfilled the requirements of the ideal plate —it resisted and broke up four projectiles of standard armor-piercing qualities, fired with velocities varying from those that would obtain at the commencement of an action at moderate range to those that would be reached by a high-power gun at 100 yards or close range. It protected from all injury the backing upon which it was mounted, even under the severe conditions of the last shot, when a fragment less than one-third of the plate was attacked by the heaviest energy employed in the test; and the plate has shown itself more than a match for any 10-inch gun afloat.

Regarding the plate as a protection for a ship, more is to be considered than the mere breaking up of and perfect resistance to all the projectiles fired at it. The question of the absorption of the energy of the blow is the cardinal point in the case. Armor, if made thick enough, can stop any projectile, but the energy, if the projectile is not broken, goes into the plate, thence into the structure in rear, and the shock and racking effects are very serious. In the case of the Harveyed plate, nearly all the energy of the blow went into the projectile in the first round, the percentage becoming less and less, of course, as the velocity increased, but even in the last round a very large part of the energy went towards breaking and heating the projectile. This plate was mounted upon the same structure and with the same structural resistance as the 14″ nickel plate of the Indiana. The weights of plates were 25 tons to 16

tons in favor of the 14″ nickel, and the striking velocity on the latter plate was 1384 f-s., or nearly 100 f-s. less than that of the first round on the Harvey plate.

Yet the heavier plate was on *each* round set back and structure was racked very much more than was the case with the lighter Harvey plate of the same thickness with shots of 1472, 1859 and 1959 f-s.

As was to be expected, the last shot with 2059 f-s. at the 4.4 ton fragment of the Harvey plate racked very severely the backing and structure on that side, but it could have still stood against another round. The difference is due to the distribution of the energy—if into the projectile, the structure or vessel is but little racked; if into the plate, the structure suffers. These features were so clearly shown in this test—more clearly than in any former trial—that I take this opportunity of bringing them prominently to the Bureau's notice, and to respectfully offer the opinion that from a naval point of view the remarkable behavior and condition of the supporting structure are fully as important matter for consideration as their immediate causes, the projectile-breaking qualities of the plate.

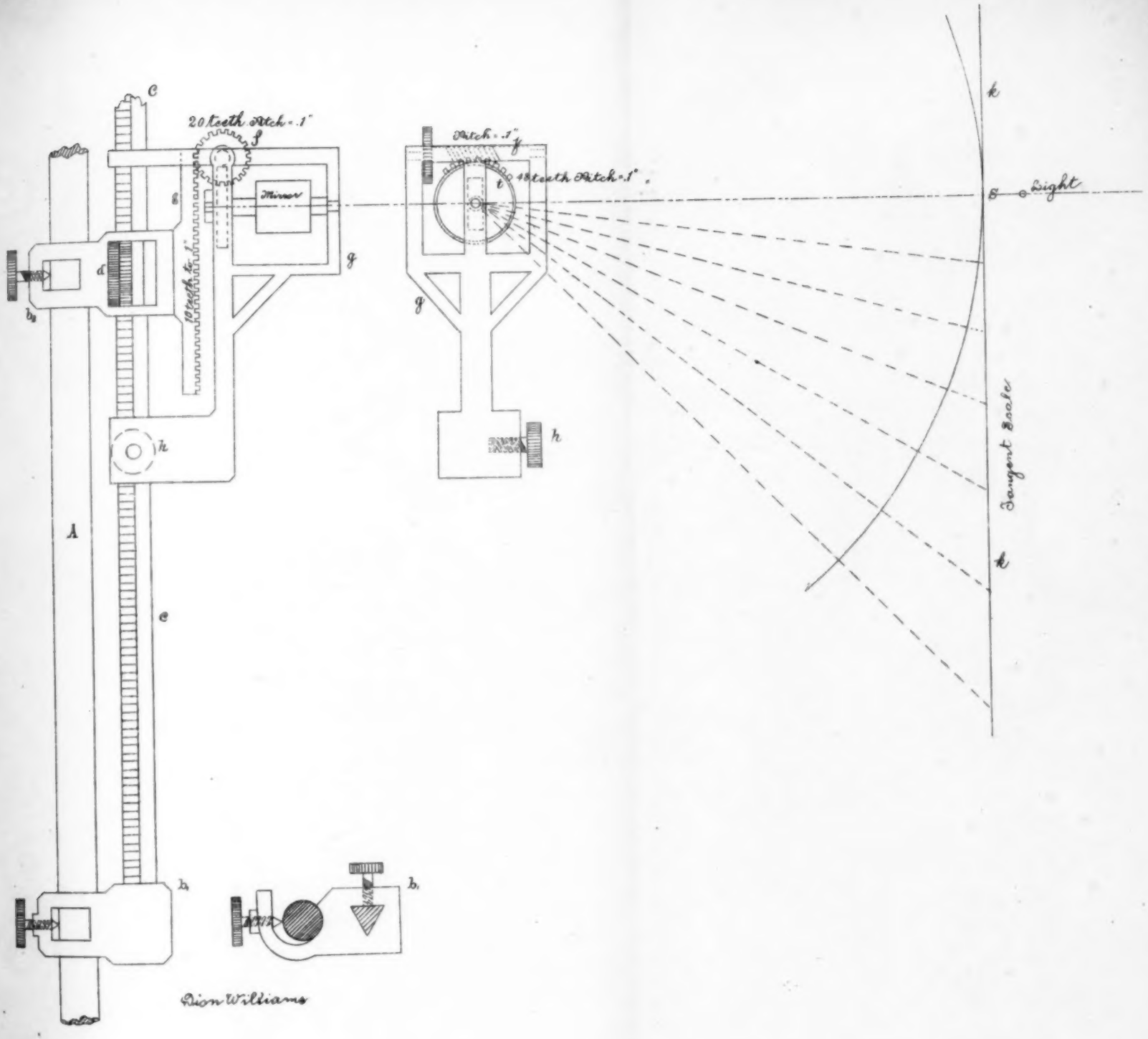
Very respectfully, your obedient servant,

R. B. DASHIELL, *Ensign, U. S. Navy,*
Inspector Ordnance in Charge.

A PROPOSED METHOD OF MEASURING THE EXTENSION OF METALS.

By DION WILLIAMS, Naval Cadet, U. S. Navy.

As every kind of metal used in the construction of ships and their armament must be tested under compression and tension, it is highly necessary that there should be some efficient apparatus for measuring and recording the exact effect of the power as it is applied. Several very complicated contrivances have been devised for thus showing the extension of a specimen bar of metal under tension, but where a large number of such specimens must be so tested the use of these complicated machines involves too much time. To replace these methods by one which is simple in design, and which may be quickly and yet accurately applied, is the object of the contrivance here explained. Referring to the diagram, the specimen bar to be put under tension is shown (A) with the registering apparatus clamped to it. It consists of the two clamps (b_1 b_2), to the lower end of which the triangular scale (c) is firmly clamped by a set screw, and the registering apparatus borne by them. On the upper clamp is a vernier (d) fitted to read the divisions of the scale, which may be graduated in any convenient units. This upper clamp is firmly clamped on the specimen bar by a set screw, and through it the scale is allowed to slide as the specimen is extended under tension; on its outer edge it bears a rack (e) which gears into the pinion (f). Now this pinion with its accompanying gearing is held in the frame (g). This frame is attached to the scale by the set screw (h) and does not move as the specimen is extended. On the shaft of the pinion is a worm (j) which gears in the worm wheel (t), the shaft of which bears a small mirror. At a given distance from the mirror is placed a screen (k) with a tangent scale on it, for the given distance. At the zero of this scale is a slit (s), back of which a light is so arranged that the spot of light showing through the slit will strike the mirror, so that the reflected image of the slit will be thrown on the tangent scale. The specimen to be extended is placed in the testing machine. The two clamps are set on the specimen at the distance apart to be used for the calculations, and the frame bearing the mirror is set so that


C
20 teeth Pitch = 1"
f
Pitch = 1"
f
18 teeth Pitch = 1"
t
Mirror
g
d
b2
g
h
h
A
e
k
Sight
Tangent Scale
k
b1
b1
Dion Williams

the pinion (f) is at the top of the rack; and the mirror is set so that the reflected image is at the zero of the vernier. As the tension is put on the bar, the scale and mirror frame being clamped at the fixed end of the specimen, will remain stationary, while the upper clamp (bearing the vernier and rack) being clamped to the movable end of the specimen bar, will move with the specimen as it is extended. By regulating the number of teeth in the rack and gear wheels, the degree of accuracy necessary for the testing of metals to be used for guns and shipbuilding may be arrived at. For instance, if there be ten teeth per inch on the rack, twenty teeth on the pinion (f) with a pitch of one-tenth of an inch, and the worm screw is cut with a pitch of one-tenth of an inch, and the worm wheel (t) have forty-eight teeth, pitch one-tenth of an inch, a tension on the specimen sufficient to give an elongation of one inch will move the mirror through an angle of seven degrees and thirty minutes. If the distance between the clamps, which is the length of the specimen whose extension is measured, be nine inches, an elongation of three inches or about 33 per centum, which is all that would probably occur in practice, would give an angle of 22° 30′. The greater the distance the screen is placed from the mirror the larger will be the distance subtended on the screen by the angle of the mirror. Now if a pressure is put on the specimen, the exact elongation will be known by the movements of the spot of light; in case the pressure be removed, the spot will return to the zero again, if there is no permanent set. If the spot does not return to the zero, then there is a permanent set, shown by the reading of the tangent scale. After the metal has reached the "elastic limit"; *i. e.* when it will not return to its original condition after a pressure producing the deformation is taken off; any further pressure only increases the deformation more rapidly than before the "elastic limit" was reached. By having an observer at the pressure indicator and one at the tangent scale, taking simultaneous readings, a curve may be constructed with these two readings for ordinates and abscissae respectively. This curve will graphically show the performance of any metal under tension, from the point of rest right up to the point of fracture. In it, as in the usual pressure and elongation curves, the elastic limit will mark the point in the curve where regularity ceases; after this point is reached the curve will not follow any particular law of extension, but will present many irregularities up to the point of fracture, where it will end. By the use of such curves all that is required to be known concerning metals under extension may be readily seen, and, after a little comparison, the correct inferences may be drawn. The means most generally employed at present for measuring the extension of specimens is by the use of a pair of micrometer calipers; but this does not admit of the large number of readings admissible by the proposed method. This device is applicable to any of the numerous extension machines where a specimen in the form of a bar of the metal is employed, as it is all attached to the specimen bar itself and not to the machine. The arrangement shown in the sketch is for a vertical tangent scale; but if it were, for any local or constructional reasons, more convenient to have the scale horizontal, it could easily be so arranged by a slight modification of the gearing in the frame (g). The distance traversed by the spot of light would, of course, depend upon the distance of the screen from the mirror. For instance, suppose this distance be a very convenient one, twenty feet. An elongation of two-tenths of an inch will move the mirror through an angle of one degree and thirty minutes. The angle of reflection will be equal to the angle of incidence, hence the actual angle traversed by the ray of light will be double this, or three degrees.

Therefore the reading of the tangent scale will be 240 inches (distance of scale from mirror) multiplied by tangent of the angle, or $240 \times \tan. 3° = 12.598$. Suppose now that sufficient pressure be added to the specimen bar to increase the elongation the one-hundredth part of an inch. This will increase the angle 9 minutes and the new reading will be $240 \times \tan. 3° 9' = 13.209$; hence the

increase will be .611 inch. This of course could be readily seen on the scale. As the extension increased, the divisions on the scale would be longer for the same angle, and hence the accuracy would be thus increased. The device may have many defects, but it is claimed that it is more accurate than the caliper measurements it is expected to replace, and that it gives a rapid and ready means of showing the conduct of any metal under tension.

The members of the Institute are requested to look over the plans and suggest any means which will improve the effectiveness of the design.

PERFORMANCE CURVES OF WAR VESSELS.

By C. M. McCormick, Ensign, U. S. Navy.

Our war vessels are usually tested for their maximum speed, and this under the most favorable conditions. Afterwards they cruise at speeds regulated by their commanding officers in accordance with the duty they are engaged upon, with a general regard to economy of fuel.

It is of great importance in times of peace to know the economical speed of our war vessels, but of infinitely greater importance for the Navy Department to know just what each vessel is capable of performing under all conditions, in order to lay out a plan of action for war. The factor of time may usually be neglected in considering the question of economical speed, but this cannot be done in war time. Practical questions involving the capability of vessels to perform certain work in a certain time must arise, and this capability should be tabulated for every vessel of the navy.

In order to tabulate this capability it is necessary to consider a great number of factors such as the varied conditions of bottom, draught, trim, different qualities of coal, condition and number of boilers used, fires, whether forced, heavy or light, efficiency of machinery, wind and sea, etc., in all the various speeds at which the vessel may have been driven. These data, for a long cruise such as our war vessels usually make, are in such a shape that it is difficult to tabulate them, and impossible to give always the correct allowances for the various combinations of factors.

On board our vessels, when under way, cards are taken once every 24 hours, whenever practicable; but the speed is not accurately taken at the time, nor is care particularly taken to have the revolutions the same for the hour in which they are taken, or the log read accurately at the beginning and end of the hour. From comparison of cards, particularly those taken under somewhat similar conditions, speed curves may possibly be drawn, but cruise after cruise may be made before sufficient data are obtained to make an accurate speed curve and corresponding curves of I. H. P. and coal consumption.

Should the curves be made for one vessel, it is impossible to determine with accuracy the curves of other vessels varying in design, or even of the same design, by calculation alone.

In order to eliminate as many of the variables as possible, I would suggest that the following tests be made on all vessels, and it will be seen that these tests will cost little or nothing over the running expenses, nor call for elaborate preparations nor measured distances, while at the same time they will give accurate performance curves and a reliable means of estimating the influence the varying factors will have under all cruising conditions, and a means of comparing the efficiencies of different ships with regard to speed, consumption of coal, etc.

At a convenient time while on a cruise, with ordinary weather and moderately smooth sea, full bunkers, clean bottom, and —— tons of stores on board, make a succession of speed tests of two hours each, with 30 minutes interval between each test. Commence the tests with sufficient revolutions to make about six knots; run two hours, observing the indicated horse-power and speed. In the 30 minutes interval between the tests increase the revolutions by 10 in the lower and by 15 in the higher speeds. With propellers of great pitch, smaller numbers than 10 and 15 will have to be taken. Continue the tests of two hours, making in each the observations of speed and I. H. P., until a speed has been reached equal to at least three-fourths of the maximum speed of the vessel.

Make the same series of tests again with fairly clean bottom and normal coal supply. After three or four months cruising, and having a foul bottom, make the series again with the bunkers full, and then again with normal coal supply.

We have given for each test the following data, viz: Tons coal, tons stores, ship's draught, displacement, I. H. P., speed, revolutions, conditions of bottom.

From these draw the curves of performance as shown in the diagram.

I wish to state here that these curves are drawn merely as illustrations. I have not the data for any vessel, nor do I know of their ever having been taken, by which accurate curves under all the conditions may be drawn.

A.

Coal 900 tons.
Bottom clean.
Displacement 5000.
Draught 20′ 6″.
a I. H. P.
a' Revs.
a'' Coal in tons per 100 miles.

B.

Coal 420 tons.
Bottom fairly clean.
Displacement 4500.
Draught 19′ 6″.
b I. H. P.
b' Revs.
b'' Coal in tons per 100 miles.

C.

Coal 900 tons.
Bottom foul.
Displacement 5000.
Draught 20′ 6″.
c I. H. P.
c' Revs.
c'' Coal in tons per 100 miles.

D.

Coal 420 tons.
Bottom foul.
Displacement 4500.
Draught 19′ 6″.
d I. H. P.
d' Revs.
d'' Coal in tons per 100 miles.

$$\frac{\text{I. H. P.} \times \text{coal per I. H. P. per hr. in lbs.}}{2240 \times \text{speed in knots}} \times 100 = \text{tons coal per 100 miles.}$$

The coal per I. H. P. per hour must be obtained from the data of the cruise, selecting those days in which an even speed has been maintained and consequently an even amount of I. H. P. developed. Care should be taken that the revolutions at the instant of taking the diagrams be the same as the average revolutions maintained for the day.

Theoretically the consumption of coal varies directly as the I. H. P. and is independent of the displacement and condition of bottom. In practice it has been found that it requires more coal per I. H. P. when relatively a great or small I. H. P. is being developed than it does when developing a medium I. H. P., and data obtained by a few months cruising at varying speeds will give the consumption for several different developments of I. H. P., and a curve may be drawn from these.

The results obtained will be, for the purpose of illustration, say—

	I. H. P.	Coal in lbs. per I. H. P. per hr.
Triple expansion engine,	500	2.7
	750	2.4
	1000	2.1
	1250	2.0
	1500	1.9
	2000 } 8000 }	1.8
	9000	1.9
	10,000	2.3

Substituting these values in the formula, we obtain a'', b'', c'', d''.

The ordinates are found in this manner because the time of each test is too short to make observations on the coal consumed, and if the time was made great enough to do so it would take several days to make a set of tests, and in the meantime the displacement would have changed, and in all probability the wind and sea also, thereby vitiating the results, which must be taken under the same conditions or accurate comparisons cannot be obtained.

The coal per I. H. P. should be the total coal used on board per I. H. P., and not that used for driving the main engines exclusive of that used in distilling, running dynamos, cooking, etc., as is sometimes taken.

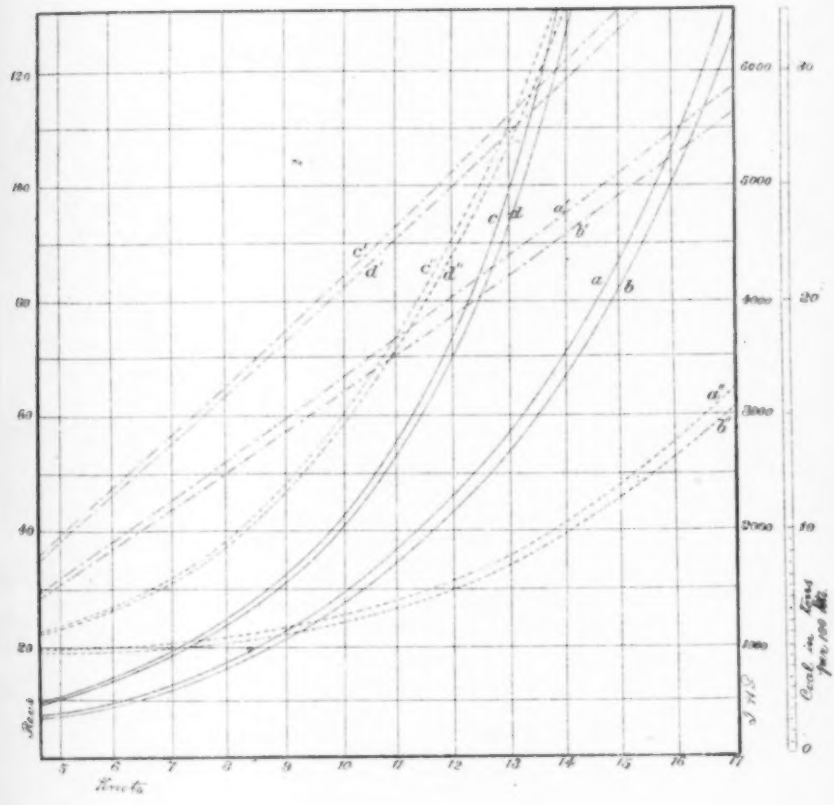
By comparison of I. H. P. developed, and not speed, thereby eliminating a large number of variable factors, it will be much easier to compare the performance of similar boilers and engines, and to find the I. H. P. to develop which it is more economical to use $n+1$ than n boilers.

After the performance curves have been drawn it will be easy to find, by comparison with them and the actual performance, the effect of a strong wind or sea, or both; a very necessary thing to know when planning certain courses.

Finally, construct a table for each vessel of the navy thus:

Name.	Coal.	Speed.	I. H. P.	No. Days.	Knots.	Coal per Day.	No. Boilers to Use.
U. S. S.....		5					
		5_f					
		6					
		6_f					
		7					
		7_f					
		8					
		8_f					
		9					
		9_f					

etc., where the n_f in the speed column means n knots' speed with foul bottom. I think these tables, while not being absolutely accurate, would be of very great value; and, as I have shown, they could be made from data collected upon the regular cruising of the vessels, under slight modifications.


120
100
80
60
40
20
Pferde
5
6
7
8
9
10
11
12
13
14
15
16
17
Knots
6000
5000
4000
3000
2000
1000
I.H.P.
40
30
20
10
0
a
b
c
d
a'
b'
c'
d'
a''
b''

ELECTRIC BALLOON SIGNALING.

[*Engineering*, February 10, 1893.]

A very interesting paper on this subject was read at a recent meeting of the Royal United Service Institution by Mr. Eric Stuart Bruce. The author has devised a system of signaling with incandescent lamps placed inside a captive balloon, the message being conveyed by means of flashes caused by interrupting the current. The usual drawback of an interrupted current does not appear—at any rate to anything near so great an extent as with naked lights—when the lamps are placed in the semi-translucent envelope of the balloon. The after-glow of the incandescent filament—a phenomenon familiar to any one who has switched off an incandescent lamp—is sufficient to so far obliterate the intervals between the flashes as to render working at a reasonable speed very difficult, if not impossible. The obstruction of the material of which the balloon is composed is sufficient to hide the glow of the carbon; although, of course, a part of the illuminating power of the lamps is lost even when fully glowing, and thus something is detracted from the distance at which the signals can be read. Probably this is more apparent than real. Our own experience is that in reading messages flashed by light, extension of area of the field illuminated largely compensates for loss of intensity. It is desirable not to have the vision too concentrated in reading quickly recurring flashes of light. Of course, in considering this, as in all such matters, the personal factor must not be forgotten; but it is certainly true—at any rate, of some persons—that a faintly luminous body is most apparent when not looked at too directly. Mr. Bruce's system, by which the electric lamps are operated from the ground, so that no person need go up in the balloon, is manifestly an improvement on the plan of using larger balloons and sending up the operators—that is, so far as sending messages at night is concerned; but it must be remembered that a general in the field wants to see as well as to speak, and for this reason the larger balloons are necessary. Again, for day signaling we are not aware that any mechanical device for using semaphores or flags has yet been devised which would be practicable to work from a small balloon. Mr. Bruce has used four different sizes of balloons. The largest has a gas capacity of about 4200 cubic feet and a diameter of 20 feet. The next size will hold 3200 cubic feet, the diameter being 18 feet; the next 2000 cubic feet, diameter 15 feet; whilst the smallest contains 1600 cubic feet, the diameter being 14 feet. For military purposes the largest is preferred by Mr. Bruce, and with pure hydrogen the lifting capacity will be over 1000 feet of electric cable. The smaller sizes, the author says, are more suitable for navy signaling, where reduction of size of balloon is of still greater importance; a statement by no means of universal application, unless it be intended to apply only to the application of Mr. Bruce's system to cases on land where an existing large-size balloon plant is already available. Carriage by sea is generally more easy than carriage by land. Lieutenant Jones, in his instructive lecture read before the Institution in February last—a notice of which appeared in our columns at the time—gave the size of the normal English observation balloon as 10,000 cubic feet. This is smaller than the war balloons of other nations, the French standard size, according to Lieutenant Jones's paper, being 19,000 cubic feet. Mr. Bruce attributes the superiority of our balloons in lifting capacity to be due to the comparative lightness of the material from which the English balloons are made,' the precise nature of which is kept secret. Mr. Bruce finds the most suitable material to be a thin cambric, which, when coated with a varnish of a light color, forms an exceedingly translucent medium. In the interior of the balloon, which is filled with pure hydrogen or coal gas, several incandescent electric lamps are placed. These are in metallic circuit with a source of electricity on the ground, where there is an apparatus for making and breaking contact rapidly. To serve the

large observation balloon of 10,000 cubic feet, 84 steel tubes filled with compressed hydrogen are required, each of these being about 8 feet long, 5⅜ in. in diameter, and weighing about 70 lbs. Each of these would contain 120 cubic feet of hydrogen. With the largest of Mr. Bruce's balloons less than half the number of tubes would be required, whilst with the smallest balloon 14 would be sufficient. Mr. Bruce has experienced some trouble in getting lamps with sufficiently fine filaments to fulfil the conditions necessary for high speed in signaling, but this difficulty he anticipates will disappear when the monopoly, due to the existing patents, expires in a few months, and he will then "have an ideal lamp, fulfilling the requisite of fine filament, moderate voltage, and suitable candle-power." The arrangement for suspending the lamps inside the balloon consists of a holder made like a ladder, so that the lamps are placed one above the other, in multiple arc. Six lamps of nominally eight candle-power, but worked much higher, gave signals which were seen at Uxbridge when the balloon was on exhibition at Battersea. The distance is about 16 miles. Experience does not show that the continuous flashing shortens the life of the lamps. The electric cable is made of strands of copper, so as to be very flexible. There is no reason why the holding rope and electric cable should not be all in one, excepting that the latter serves as a guy-rope to keep the balloon steady in case of wind. The first cable weighed 40 lb. per 500 feet of twin cable, but this weight has been reduced to 30 lb. for the same length.

As a source of electric power, Mr. Bruce generally uses storage batteries and when a dynamo is available these answer best. When taking part in the military tournament at Cork, the cells were charged in London, and when they arrived at Cork they needed no replenishment. They were sent back to London, and were found to be nearly fully charged eight weeks after. The storage battery generally used consists of 25 cells; each cell weighs 24 lb. The size of each cell is 4 in. long and 7⅛ in. wide. Its height is 13¾ in. The whole set of 25 cells takes only a space of 3 ft. by 1 ft. 8 in. When a dynamo is not at hand for recharging the cells, it is necessary to have a diminutive engine and dynamo to supply the current; or a small gas engine worked by the hydrogen gas might be used. It is interesting to state that on the occasion of a trial at Chatham by the military authorities, Mr. Bruce's balloon was filled with hydrogen that had actually been used for balloon inflation at Suakim during the Egyptian War, and had been rebottled. . . . . .

The lecturer made some experiments to show that there is no danger from explosion owing to the lamps being immersed in the hydrogen gas. Unless there were a proper mixture of oxygen, there would, of course, be no combustion, and if the hydrogen became diluted to this extent the balloon would no longer float. He also proved by experiment that bullet-holes are not so fatal as would at first be supposed, especially if in the lower part of the balloon, owing to the pressure of the gas being upwards.

The great enemy to the captive balloon is undoubtedly wind, but that, naturally, does not apply to the same extent to balloons which do not carry a car or any living freight. The author says he can do much by a skillful use of guy-ropes, and he made a successful exhibition before the military authorities at Stamford Bridge in half a gale of wind.

There can be little doubt of the immense importance that signaling and observation by captive balloons may have in future warfare. There are many occasions in history when such a means of communication might have turned the fortunes of the day. In this respect, however, we cannot do better than quote Mr. Bruce's concluding words: "It is but a few years ago there was a general shut up with a few followers in a besieged city. Near at hand there were friends to help, but ignorant of the immediate necessity. If from Khartoum there had arisen such an electric signaling balloon as I have described, its flashes of light in the skies would have told the tale of the events below, and perhaps the heroic leader would have left Khartoum a conqueror, with his life spared for the future service of his country that he loved so well."

A NEW PERCUSSION FUZE.

By Henry P. Merriam.

[Reprinted, by permission, from the *Journal of the United States Artillery*, January, 1893.]

The fuze to be described in this article was the outcome of a series of experiments made at the Sandy Hook Proving Grounds during the years 1890–91. It was the purpose of these experiments to produce a base percussion fuze which would be suitable for shells of the larger calibers, and more especially for rifled mortar shells. The chief requirements to be fulfilled were:

1st. Safety, in handling and transportation; 2d. Certainty of action upon concussion on a target; this to mean that a burst should occur whether the shell strikes point foremost or sidewise; 3d. Delay after concussion, to allow time for the shell to penetrate before exploding. . . . .

The fuze as now constructed will be readily understood from the following description and diagram.

Figure 1 shows a longitudinal section of the fuze, showing parts as they exist previous to firing.

Figures 2 and 3 are end elevations.

Figures 4 and 5 are sections along *x-x* and *y-y* respectively, looking in the direction of the arrows.

Figure 6 shows, in separate view, the valve upon which the delay action depends.

Referring to Figure 1. In the fuze case which screws into the base of the shell, the plunger or hammer *A* for exploding the caps is in the form of a sphere. This is held securely in the position shown by the clips *B*, *B*, which abut at one end against a circular recess in the ball, and at the other end against a shoulder in the fuze case. When, in the discharge of the shell, pressure is applied to the trips *C*, the clips *B*, *B* are forced off from the shoulder in the fuze case and thus free the hammer *A*. A flat spring *D* serves to keep the ball to the rear of the cavity during the flight of the shell.

When the velocity of the shell is suddenly checked upon striking a target, the ball, by its momentum, strikes one or more of the small balls *E*—see also Fig. 4—placed above the fulminate caps *F*, and explodes the latter. The resulting flame escapes through the channels *G*—see also Fig. 5—into the chamber *H*. It is also evident from the arrangement of the ball *A* and its surrounding cavity that should the shell strike squarely on its side, the ball in being thrown to one side of the cavity is forced to move forward and thus explode at least one of the caps. In the chamber *H* is placed the delay mechanism, which consists of a disk *I* of closely pressed powder carried on the front of the valve *J*. This valve is capable of a slight movement in an axial direction. This disk of powder, when compressed between two surfaces and ignited at the edge, burns in successive concentric rings, and it requires an appreciable time for the flame to reach the center; when the disk is not thus compressed the igniting flame reaches the center immediately.

At the instant of impact the sudden stopping of the shell causes both the hammer *A* and the valve *J* to move forward, but the valve *J*, on account of its shorter travel, reaches its seat an instant before the hammer strikes the caps. When the flame from the fulminate caps enters the chamber *H*, the valve *J* is pressed firmly against the front surface, and the flame ignites the edge of the disk of powder through the windows *K*—see Fig. 6. As long as the shell is undergoing retardation, the disk *I* remains forced against the forward face and the flame advances slowly, as before stated; when the shell has passed through or has stopped in the target, this force, due to the momentum of the valve, ceases, and the gas pressure between the two surfaces forces the valve away from the forward face, thus allowing the flame to at once reach the center. A

wisp of dry gun-cotton closing the channels *O* serves to conduct the flame to the powder contained in the radial chambers *L*, and from thence it passes to the bursting charge in the shell; these chambers *L* contain supplemental flashing charges to further ensure the ignition of the bursting charge.

A screw *M*, when screwed down, serves positively to hold back the valve *J*, should it be desired to have the explosion as nearly instantaneous as possible at all times.

The pistons on the trips *C* are rendered gas-tight by means of copper caps, arranged after the usual manner of crusher gauges, and tallow or wax fills the space above these.

When screwed into the shell, leakage of the powder-gas by way of the threads is prevented by a washer at the shoulder *f*, *f*.

The small balls *E* are secured in place by being set in the recesses somewhat deeper than half a diameter; a burr at the edge of the recess then holds them.

The safety of this fuze in handling has been abundantly tested by dropping and throwing about. As for certainty of releasing upon discharge, this is fully secured by the size of the pistons and the fact that there are two; either one releasing being sufficient. Certainty of exploding upon striking is secured by employing three percussion primers instead of one; that three defective caps should happen to be in the same fuze is wellnigh impossible. Finally, the delay mechanism for mortar shells would seem to be all that could be desired. It may be said by way of anticipating a criticism, that the apparent complication is due to a duplication of parts which secures greater certainty of action: over sixty of these fuzes have been fired and not one has failed to act.

MERRIAM BASE PER

WITH

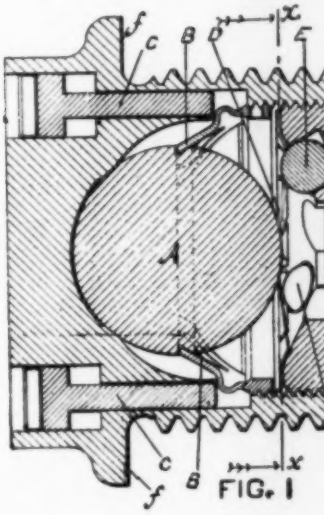


FIG. 1

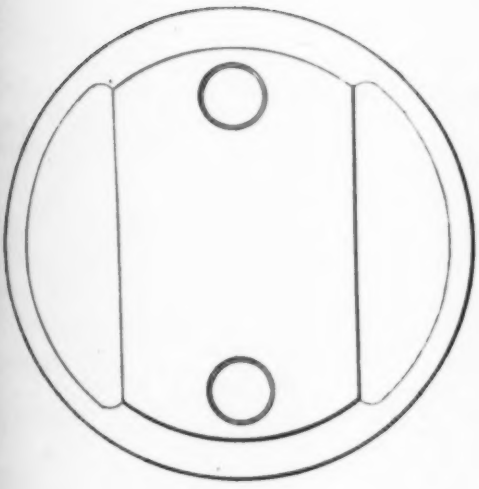


FIG. 2

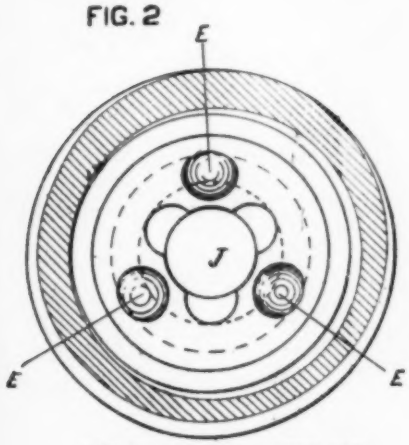
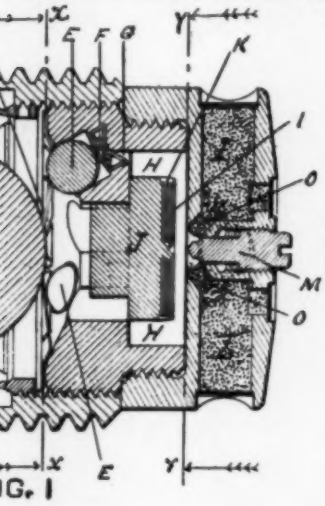


FIG. 4 — SECTION ALONG ✖ ✖

FIG. 6 - VALVE FOR CONT

PERCUSSION FUZE.

WITH AUTOMATIC DELAY.



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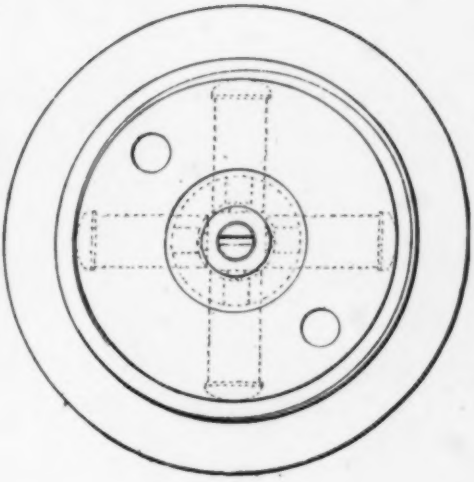
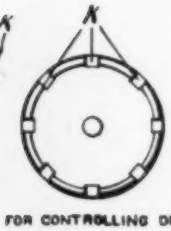


FIG. 3



FOR CONTROLLING DELAY

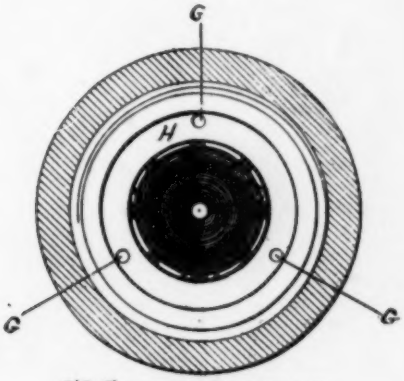


FIG. 5 – SECTION ALONG YY

BOOK NOTICES.

THE CAPTAIN OF THE MARY ROSE; A TALE OF TO-MORROW. By W. Laird Clowes, Member of the U. S. Naval Institute. The Tower Publishing Company, London.

The author of this very interesting book will be remembered by the readers of the Proceedings as the Institute prize essayist for 1892; and he has paid the Institute a graceful compliment by subscribing himself a member on the title-page. The book was no doubt written with an object—to arouse Englishmen to the necessity of being at all times thoroughly prepared in their first line of defense. An affray at Toulon between some English and French sailors precipitates the war necessary for the author's purpose. At first everything goes the way of the French; the English Mediterranean Squadron is soundly whipped by the French fleet, and close upon this disaster comes the destruction of several ships at Spithead by a torpedo-boat flotilla, while Gibraltar is blockaded and bombarded. The hero of the story is a lieutenant, whose name was stricken from the navy list at the beginning of hostilities for indiscretion in sending dispatches to the *Times*. He will not be shelved, however, so he buys an armored cruiser by the aid of wealthy friends, names her after his fiancée, and goes to sea as a free-lance. With his advent comes an entire change of luck. He runs by the French fleet off Gibraltar, sinking or disabling two cruisers and an armored ship, and makes his way to Malta with an important dispatch, stopping *en route* to whip in detail the three fast ships sent in chase. He is permitted to sail with the fleet from Malta and, in the final engagement, which naturally redeems Britain's prestige on the sea, he wins further laurels. The story ends with valor rewarded and domestic bliss assured. Mr. Clowes, although not an officer, has made a serious study of naval matters; and professional men will note with interest his opinions thereon as brought out in the course of his story, and will regret that he has not seen fit to enlighten us as to his views on actions by daylight, as all his engagements take place at night. The illustrations by the Chevalier de Martino and Mr. Jane add much to the general attractiveness of the book.

H. S. K.

MODERN GUNS AND SMOKELESS POWDERS. By Arthur Rigg and James Garvie.

This little work of 82 pages is very readable and contains considerable information regarding modern improvements and future possibilities in the development of ordnance and explosives. Technical language is avoided, and the subjects are handled in a manner that renders them easily understood by a layman. A good idea can be obtained of the action of gunpowder in the bore of a gun, and of the effect upon the velocity and pressure of making certain changes in the character of the powder. There is a short description of the principal high explosives and of the machinery used in their manufacture. The peculiarities of these explosives are referred to and their relative advantages for certain purposes are made apparent. The discussion of smokeless pow-

ders is brief, but it is sufficient to give an intelligent idea of the subject and of its effect upon gun construction and modern warfare. As an elementary treatise, aiming at brevity and simplicity, this little book can be well recommended.

W. F. F.

CYCLISTS' DRILL REGULATIONS, UNITED STATES ARMY. By Lieutenant William T. May, M. A.

CYCLE-INFANTRY DRILL REGULATIONS. By Brigadier-General Albert Ordway.

These two little manuals are interesting, in view of the possible adoption of the bicycle for military purposes. A beginning has already been made, both in this country and abroad, and with the improvement of country roads, the bicycle will no doubt be used extensively in operations of war. The movements in these manuals are very simple and are based upon the new Drill Regulations for Infantry. The work of General Ordway is the more complete of the two and is very well illustrated.

W. F. F.

BIBLIOGRAPHIC NOTES.

AMERICAN.

CASSIER'S MAGAZINE.

VOLUME III., NO. 13, NOVEMBER, 1892. The Analysis of Cylinder Deposits. The Life and Inventions of Edison.

NO. 14, DECEMBER. The Electric Search Light.

An illustrated popular article.

The Life and Inventions of Edison (continued).

NO. 15, JANUARY, 1893. Black Prints.

Notice of an improved process of printing black lines on a white ground.

The Life and Inventions of Edison (continued).

NO. 16, FEBRUARY. Mechanical Flight.

An interesting discussion of the question, stating the difficulties that have been overcome and those that remain.

The Life and Inventions of Edison (continued). W. F. W.

ILLUSTRATED ELECTRICAL REVIEW.

VOLUME XXI., NO. 17, DECEMBER 17, 1892. Electricity in the Art of War.

The first of a series of papers by Lieut. Parkhurst, U. S. A.

DECEMBER 24. A Compact Marine Installation. Electricity in the Art of War (continued).

DECEMBER 31. Electricity in the Art of War (continued).

JANUARY 7, 1893. Electricity in the Art of War (concluded).

JANUARY 28. An Electric Torpedo Detector.

FEBRUARY 4. A New Submarine Boat. C. M. K.

IRON AGE.

VOLUME L., NO. 22, DECEMBER 1, 1892. Pneumatic Pumping Apparatus, I. The Worthington Sectional Water Tube Boiler.

DECEMBER 8. The American Society of Mechanical Engineers; Proceedings of the 13th Annual Meeting. Hollow Shafting in Modern Steamships. The Utilization of Niagara Falls.

Early projects and plans now being developed.

Pneumatic Pumping Apparatus, II.

DECEMBER 15. Telegraphy by Induction.

If a cable is used in the ordinary way to connect a light-ship with the shore, trouble is experienced from the fouling of this cable with those anchoring the ship. To avoid this difficulty, experiments are being made by the authorities of the British Post Office. The attempt is being made to communicate by means of two distinct circuits, one on the light-ship and the other including the shore station, these two circuits to act on each other inductively.

Steamship Efficiency.

A comparison of the efficiency of a number of the fastest mail steamers, considering displacement, speed, and coal consumption.

DECEMBER 29. A French Steamship Mobilization Trial.

An experiment on the Normandie to determine the time required to convert a passenger vessel into an auxiliary cruiser.

VOLUME LI., NO. 2, JANUARY 12, 1893. Liquid Fuel Trials in France.

JANUARY 19. Nickel Steel.

Result of tests of boiler plate steel, with and without nickel, made at the Cleveland Rolling Mill Company's works, the results being increase of limit of elasticity and tensile strength without reduction of ductility when containing about 3 per cent. of nickel.

JANUARY 26. Rudder of the Battleship Oregon. Hardened Copper. The Edwards Valve Gear.

FEBRUARY 2. The Shaw 80-ton Gantry and Transfer Crane.

A description, with illustrations, of a new crane for mounting and dismounting heavy guns at the Sandy Hook proving grounds.

A Danish Naval Trial of Water Tube Boilers.

Details of the successful trial of the cruiser Geiser fitted with Thornycroft boilers.

FEBRUARY 23. The Sellers 40-ton Dock Crane.

Detailed description of the crane now in use at the N. Y. navy yard.

The New Armor Specifications.

The new specifications for the armor required by the Navy Department.

The Trial Trip of the El Rio. The Submarine Cable Systems of the World. C. M. K.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

VOLUME IV., NO. 4., NOVEMBER, 1892. Speed Trials.

Article discussing the present method of conducting speed trials, and proposing certain improvements.

Coal Endurance and Machinery of the New Cruisers. The Allen Dense-Air Ice Machine. Ships (U. S.).

Under this head are given particulars of the new armored cruiser (No. 3) Brooklyn and the sea-going battleship (No. 1), with notes on the Olympia and Cincinnati just launched.

W. F. W.

JOURNAL OF THE FRANKLIN INSTITUTE.

FEBRUARY, 1893. The Priestman Engine as manufactured in America.

Description and discussion of the American modification of the Priestman petroleum engine. According to the writer, Mr. Coleman Sellers, E. D., this engine has proved very efficient and economical where used to develop small powers, and has the great advantage of not requiring expert attendance.

Manganese Steel. By Henry M. Howe.

This metal exhibits a remarkable combination of hardness and ductility, when made in certain proportions (about 13 per cent of manganese) and water-quenched. The paper compares tensile strength, ductility, and hardness of carbon, nickel, and manganese steels. Test bars of the last named under tensile stress do not "neck" to any great extent, but the reduction of area is well distributed over the bar between the shoulders. The paper is to be continued.

H. S. K.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

VOLUME XIV., NO. 61, JANUARY, 1893. Hot-Air Balloons. The Knapsack. Musketry Training.

Captain Parker, 4th Cavalry, makes a strong plea for thorough musketry training and fire discipline. He points out where the present firing regulations can be improved, especially in the directions of simplicity and greater prominence of skirmish firing, and advocates rapidity of fire, both at the butts and in skirmish firing.

Artillery in Coast Defense. Infantry in Combat (trans.). Aerial Navigation. Military Notes: A New Mannlicher Rifle; Professor Hebler on the Best Form of Bullet.

NO. 62, MARCH. Prize Essay: The Army Organization Best Adapted to a Republican Form of Government. The Evolution of Modern Drill Books. Comment and Criticism: II., Whistler's Graphic Tables of Fire, Jump; III., The Knapsack; IV., Musketry Training and its Value in War; V., Military Specialists. Artillery in Coast Defense. Changes in Military Matters. Letters on Strategy, by Hohenlohe (trans.). Military Notes: Continental Methods of Attack; The Souchier Prism-telemeter; The New German Field Artillery. H. S. K.

JOURNAL OF THE UNITED STATES ARTILLERY.

VOLUME I., NO. 5, OCTOBER, 1892. Krupp *v.* Canet Guns. Schneider & Co. 15-cm. Q. F. Guns. Quick-firing Guns.

The number is an extra one and consists practically of papers on the above subjects, reprinted from the columns of *Engineering*. The first subject is made up of an editorial article in *Engineering*, a paper by a French artillerist, a reply by a German artillerist, and a counter reply by a French artillerist. The whole number is a valuable collation of information about foreign guns.

VOLUME II., NO. 1, JANUARY, 1893. A New Percussion Fuze. Some Applications of Glennon's Velocity and Pressure Formulas. Electricity and the Art of War (discussion continued). The Artillery Fire Game (trans.). H. S. K.

RAILROAD AND ENGINEERING JOURNAL.

VOLUME LXVI., NO. 12, DECEMBER, 1892. The First Light-ship with Electric Lights.

Account of the electric plant of Light-ship No. 51, off Cornfield Point, Long Island Sound.

The New Breech-loading Mortars.

Description of manufacture and design of the 12-inch mortars of cast iron hooped with steel, for 73 of which the Builder's Iron Foundry, Providence, R. I., has a contract.

Recent Patents: Pollock's Water Tube Boiler.

AMERICAN ENGINEER AND RAILROAD JOURNAL. (Title changed to above with beginning of new volume.)

VOLUME LXVII., NO. 1, JANUARY, 1893. The New Mannlicher Rifle.

An automatic repeating rifle.

A Quadruple Expansion Marine Engine.

Illustrated description of engines for the Duke of Westminster.

Home Naval Notes: A Ship with Gasoline Engines.

Auxiliary power applied to a schooner for service among the Pacific islands.

NO. 2, FEBRUARY. Recent Inventions in Armor. The Ochta Armor Trial. The Manufacture of Rifles.

Abstract of paper read by Mr. John Rigby, Superintendent of the Enfield Rifle Factory, before the English Institution of Civil Engineers, describing the manufacture of the Lee-Metford rifle.

Home Naval Notes. C. M. K.

TRANSACTIONS AND PROCEEDINGS OF THE GEOGRAPHICAL SOCIETY OF THE PACIFIC.

VOLUME III., 1892. Recent Visual and Photographic Astronomy. Cable Surveys, by Lieutenant-Commander Z. L. Tanner.

The author gives a résumé of the surveys between California and the Sandwich Islands made by Captain (now Rear-Admiral) Belknap, Comdr. Reiter, and himself. H. S. K.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

VOLUME XIII., 1892. XIV. MEETING, NOVEMBER, 1891. Rules of the Society. The Evolution of American Rolling Mills (President's Annual Address). The Brooklyn Pumping Engines of 1860. Electric Power Distribution. Influence of the Steam Jackets of the Pawtucket Pumping Engine. Appendices III. and IV. to the Report of a Committee on Standard Tests and Methods of Testing Materials (trans.).

XV. MEETING, MAY, 1892. A Self-lubricating Fibre Graphite for the Bearings of Machinery.

This material is said to give excellent results when used for bearings and brushes in dynamos and electric motors.

Utilization of the Power of Ocean Waves.

The writer, Mr. Albert W. Stahl, U. S. N., discusses at some length the trochoidal theory of sea-waves, and in conclusion presents a device for utilizing the power of sea-waves, which he believes to be novel in principle, and from which he anticipates more satisfactory results than those hitherto obtained from machines for the same purpose.

On the Elastic Curve and Treatment of Structural Steel. A Novel Fly-wheel.

A description of a fly-wheel designed by Passed Assistant Chas. H. Manning, U. S. N., to replace the fly-wheel of a pair of large Corliss engines belonging to the Amoskeag Manufacturing Company, of Manchester, N. H. In this instance Mr. Manning appears to have added one more to the many engineering successes that have marked his connection with the Amoskeag Co.

J. P. M.

FOREIGN.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

XXTH ANNUAL SERIES, 1892, VOLUME IX. Mona Island, West Indies (chart). Recent Hydrographic Researches in the Black Sea. Three Years of Storm Predictions on the German Coast. A Demand for Observations of Luminous Clouds. Magnetic Observations at the Mouth of the Elbe. Hydrographic Information on the East Coast of Africa from the Red Sea to Suez Canal. Hydrographic Notes on the West Coast of Africa. A Voyage from Sydney to Apia. Notes on the Passages and Harbors on the North Coast of Java. Minor Notices: The Weather on the German Coast for August, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory at Wilhelmshaven in August, 1892.

VOLUME X. Six Voyages of the Bark Eduard. Extracts from a report on a voyage in the tropical part of the Indian Ocean. A review of lectures on Ocean Geography. The Winds at Trieste. Voyage of the German Cruiser Bassard. Voyages in the Gulf of Guinea. Minor Notices: Anchorage at Mona Island; Hurricane at Marseilles; Whaling in the Antarctic; Aerostatic Voyages for Scientific Purposes; The Weather on the German Coast for August, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in September, 1892.

VOLUME XI. Tropical Revolving Storms in the Southern Indian Ocean. The Great Atmospheric Currents. Minor Notices: Storm in the North Atlantic Ocean on the 4th and 5th of October, 1892; Sun Spots observed in the Years 1889–1892; A Fifth Moon of Jupiter; Remarkable Atmospheric Phenomena; Change of Date at Samoa; Drift of the Parts of a Wreck in Contrary Directions; Emma Harbor at Padang, Sumatra; Key Islands; The Weather on the German Coast for October, 1892, with Tables. Tables: Meteoro-

logical and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in October, 1892.

VOLUME XII. The Discovery of America; a Turning-point in the Commerce of the World. The Winds at Trieste (conclusion). The new Harbor of Leixois, near Oporto, Portugal (with plan). Description of the North Coast of Formosa. Tide Signals at Tamsui Bar. Hydrographic Notes on the West Coast of Africa. Notes on the Passage between Chusan and Kinho Island. Hydrographic Notes on the East Coast of Asia. Voyages on the West Coast of Africa. Bottle-post. Minor Notices: Luminous Phenomena of the Heavens; Aurora Australis; Cayman Islands, West Indies; The new Volcanic Island, Falcon I., in the Tonga Group; The Weather on the German Coast in November, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in November, 1892.

XXIST ANNUAL SERIES, 1893, VOLUME I. Sailing Routes in the English Channel. Mean Daily Variation in the Declination at Wilhelmshaven, from 1883–1885. Instructions of the London Board of Trade in Regard to the Inspection of Running Lights. Review of the Weather in Germany in 1892. Weather, Wind, and Currents on the Coast of Venezuela (Harbor of La Guayra), between June 9th and October 9th, 1892. Extracts from the Cruising Report of Captain Nichelson, of the German Bark "Theodore." Voyage from Bremerhaven to Cape St. Lucas; Mazatlan; Wind and Weather on the West Coast of Mexico during the favorable seasons, Winter and Spring; San Pedro and Cuidad de David, Province of Chiriqui, Colombia; Voyage from San Pedro to Falmouth. Minor Notices: Fernando Noronha; History of the Origin of the West Coast of Normandy; The Weather on the German Coast for December, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in December, 1892; Summary of the Meteorological Observations at Wilhelmshaven in 1892. H. O.

BOLETIN DEL CENTRO NAVAL.

VOLUME X., JUNE, 1892. The National Manufacture of Dynamite.

Describes a new dynamite manufactory.

Modern Constructions: the Cruiser Patagonia.

JULY. The Wreck of the Torpedo-boat Rosales.

OCTOBER. Torpedo-boat Tactics (with plates), from the *Revista General de Marina* (continued, see p. 205). Modern Constructions—Plan of a Rapid Cruiser (continued). Battle-ships of the Most Modern Types; American Compared with European Designs.

NOVEMBER. Torpedo-boat Tactics (ended).

Nearly the whole number is taken up by the plea in favor of a second class sailor belonging to the crew of the cruiser Patagonia, read before a court martial convened on board the same vessel. It is not without interest.

J. L.

THE ENGINEER.

NOVEMBER 18, 1892. The Vickers Harvey Armor Plate. The Argentine Twin-screw Armor-clad Ram Libertad. Stern-wheeler for the French Government. H. M. S. Revenge.

DECEMBER 2. Editorial—The Russian Armor-plate Competition. The Russian Navy—the Ruric.

DECEMBER 9. Breech-loading Rifled Mortars for the U. S. Government.

DECEMBER 16. Notes on Recent Russian Armor-plate Trials.

DECEMBER 23. Editorial—The Auxiliary Fleet of France.

JANUARY 13, 1893. The Gun Trials of the Twin-screw Armor-clad Ram Libertad. H. M. S. Bonaventure. The Howe Court-martial. Stay Tubes in Marine Boilers.

JANUARY 20. The Repair of the Umbria's Screw Shaft. Harvey Plate Trial.

Test of a Harvey nickel steel 6-inch plate on board the Nettle at Portsmouth.

JANUARY 27. The Cunard Company's New Twin-screw Steamship Campania.

FEBRUARY 3. New Canet Guns and Fittings. Velocities with Modern Guns and Explosives.

Letter to the editor from A. Noble, F. R. S.

FEBRUARY 10. Cordite.

Editorial article in which are given the constituents and ballistic qualities of cordite, the new English smokeless explosive for rapid-fire guns.

FEBRUARY 17. The 9 de Julio.

Trial of the protected cruiser built by Armstrong, Mitchell & Co. for the Argentine navy. On the continuous six hours' run under natural draught, the very high average speed of 21.9 knots was made.

The Worthington Patent Marine Feed-water Heater.

C. M. K.

ENGINEERING.

VOLUME LIV., NO. 1402, NOVEMBER 11, 1892. Trial Trips: the Russian Cruiser Rurik. Two New Battleships, the Revenge and Royal Oak. The Treatment of Marine Boilers (concluded).

NOVEMBER 18. H. M. S. Vulcan.

The Vulcan is a torpedo depot ship, and is quite fully described, especially in her peculiar features of 20-ton hydraulic davits for handling her six second class torpedo-boats, her very complete steam repair shops, and her equipment for laying mine fields.

Graving Docks: the Halifax, Cockatoo in N. S. W., and the Alexandra in Belfast. The Argentine Twin-screw Amor-clad Ram Libertad.

DECEMBER 2. The Iron Industry of Spain. The Manufacture of Small Arms.

Description of methods used at the Enfield factory.

DECEMBER 9. Board of Trade Electrical Standards. The Value of the Steam Jacket (2d report).

DECEMBER 16. The Value of the Steam Jacket (continued).

DECEMBER 23. Launches and Trial Trips.

Launch of the Japanese protected cruiser Yoshino, which is expected to attain a speed of nearly 23 knots, and which will be the fastest cruiser afloat, if successful. Trials of H. M. ships Jason and Scylla.

The Utilization of Niagara. The Thornycroft Boiler.

Experiments in Denmark with the cruiser Gaiser.

Armstrong Quick-firing Guns. Shipbuilding and Marine Engineering in 1892. The Value of the Steam Jacket.

DECEMBER 30. Shipbuilding in Scotland and Ireland. Additions to the Navy.

A résumé of the British warships floated in 1892.

Naval Engineers. Butt Connections of the Shell-plating of Large Vessels.

Abstract of a paper contributed to the *Zeitschrift des Vereines Deutscher Ingenieure* by Herr Middendorf.

VOLUME LV., NO. 1410, JANUARY 6, 1893. Boiler Tube Fastenings. The Danish Cruiser Gaiser. Shipbuilding and Marine Engineering in England (N. E. Coast).

JANUARY 13. The Boilers of the Danish Cruiser Gaiser. A Multiple Projectile or Compound Gun.

This is a project for obtaining very high velocities of projectile for the purpose of studying air resistance. It is proposed to fire the ultimate projectile from a gun-barrel which is itself fired as a projectile from a larger gun.

Launches and Trial Trips: trials of the Brilliant and Jason. The Weather of the Year 1892. The Gun Trials of the Libertad. Marine Boiler Furnaces (begun). Heat and Chemical Energy.

JANUARY 20. The French Projects in Northern Syria. The Strength of Torpedo-boats (illus.).

Gives an account of the collision of a Yarrow 80-ton boat, moving at a speed of 18 knots, with a grain barge at anchor. Although the bow was much stove in and the forefoot bent nearly at right angles to the keel, no shifting of machinery nor breaking of steam joints occurred, and the boat returned to port under her own power.

The Three-wire System of Electric Distribution. The Development and Distribution of Power from Central Stations (by Prof. Unwin). Marine Boiler Furnaces (continued). Index to Vol. LIV.

JANUARY 27. Measuring Stellar Photographs. The Proposed Bruges Ship Canal. The Mounting of Navy Guns. The Development and Transmission of Power, etc. (continued). Marine Boiler Furnaces.

FEBRUARY 3. The Edison Triple-expansion Engine and Multipolar Dynamo. H. M. S. Jason. Measurement of Alternating Electric Currents. The Development and Transmission of Power, etc. Screw Propellers. Trials: the Argentine Cruiser Nuovo de Julio.

FEBRUARY 10. Thornycroft's Screw Turbine Propeller.

Description, particularly of means adopted to give backing power.

The Practical Measurement of Alternating Electric Currents. The Development and Transmission of Power, etc. Electric Balloon Signaling. Screw Propellers.

FEBRUARY 17. The Practical Measurement of Alternating Electric Currents (continued). The Development and Transmission of Power, etc. H. M. S. Grafton.

FEBRUARY 24. The Nicaragua Canal. Marine Boilers (editorial). The Mercantile Marine in War. Steam Trials of the 9 de Julio. The Practical Measurement of Alternating Electric Currents (concluded). H. S. K.

HEERES-ZEITUNG.

OCTOBER 1, 1892. Vegetable Diet in Principle and in Practice, Especially in its Bearing upon the Subsistence of an Army.

OCTOBER 5. A French View on Infantry Battle Tactics. The Swiss Army in 1891.

OCTOBER 8. The Swiss Army in 1891.

OCTOBER 15. The Military Budget of Austro-Hungary.

OCTOBER 22. The recent Landing Manœuvres near Cuxhaven, Germany.

NOVEMBER 9. Why Germany must increase her Military Strength.

NOVEMBER 16. French Battle Tactics.

NOVEMBER 23. The French Military Budget for 1893. The Reserves in the French Manœuvres of 1892.

NOVEMBER 26. The Military School at St. Cyr. French Battle Tactics (conclusion).

NOVEMBER 30. Outline of the Military Bills of Germany.

DECEMBER 3, 7 and 14. The Civil War in Chili.

DECEMBER 17. Auxiliary Cruisers.

A criticism of their use in war, and of the manner of arming them.

FEBRUARY 4, 1893. The debate on the German Navy before the Budget Commission. Submarine Boats.

A criticism on the advance made in their construction, and their usefulness.

FEBRUARY 8. England's Position in the Mediterranean.

FEBRUARY 15. A Frenchman's Criticism of the recent Grand Manœuvres of the French Army. H. O.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXVI., No. 177, NOVEMBER, 1892. The Russian Navy (trans.). Regulations for Mobilization for Home Defense, Regular Forces.

No. 178, DECEMBER. The Strategic Position in the Mediterranean (trans.). The Magazine Rifle Question (trans.).

A short paper full of valuable statistics.

A short account of the French Marine Infantry.

VOLUME XXXVII., No. 179, JANUARY, 1893. Ventilation of Ships.

This question, which is still several removes from final solution, is presented by Capt. MacIlwaine, R. N., who believes in the system by which foul air is exhausted. In this he is supported in the discussion. The matter of providing fresh-air inlets when natural openings are closed is touched upon, but not in a very satisfactory way.

H. S. K.

MILITÄR WOCHENBLATT.

OCTOBER 8, 1892. Tests with Aluminium.

OCTOBER 12. Review of the Latest Military and Technical Discoveries and Inventions.

OCTOBER 15. Review of the Latest Military and Technical Discoveries and Inventions (conclusion). Increase of the French Navy during the Current Year.

A summary of the vessels in course of construction.

OCTOBER 19. Review of the Swiss Autumn Manœuvres.

NOVEMBER 2. History of the German War-ships Kronprinz, Friedrich Carl, and Arminius.

A review of the history of these three vessels, which were lately stricken from the German Navy list.

NOVEMBER 5. Why Germany Must Increase her Military Power.

NOVEMBER 9. History of the German War-ships Kronprinz, Friedrich Carl, and Arminius (conclusion).

NOVEMBER 23. The Advantage of Number and Quality in Troops in War.

NOVEMBER 26. The Advantage, etc. (continued). Reorganization in the Russian Army.

NOVEMBER 30. Organization of the Russian Reserves. A New Naval Academy.

A criticism of the Naval War College.

New Guns in Russia.

A brief description of two new guns adopted in the Russian army, one for field artillery and the other for heavy artillery.

DECEMBER 3. The Recent Law for the Organization of the French Army.

DECEMBER 7. The Eastern Frontier of France.

DECEMBER 10. Hardened Nickel-steel Armor.

A brief review of the results of recent armor tests in the United States and England.

DECEMBER 17. Summary of the German Navy List for 1893.

DECEMBER 21. Organization of the French Army for War. Armament of the French Fleet.

A summary of the additions to and changes in the guns of the French navy.

DECEMBER 24. Organization of the French Army for War (conclusion).

JANUARY 2, 1893. Test of the Harvey Armor Plate in Russia. A North American's Criticism of the Recent Ride between Berlin and Vienna.

JANUARY 11. The Grand Artillery Practice at Chalons, and Lessons taught by it.

JANUARY 14. The Present Organization of the French Artillery.

FEBRUARY 8 AND 12. Trial of the 6-cm. Krupp Rapid-fire Gun.

A description of the gun and the result of extended trial of it in 1891 and 1892.

SUPPLEMENT.—NOS. 8 AND 9, 1892. Observations on the Russo-Turkish War of 1877–78, and Contributions to the History of the Same.

No. 1, 1893. Lecture on the Ride from Berlin to Vienna. The Pursuit from Jena to Prenzlau (a lecture).

No. 2. Abstract of the History of the Prussian Royal Engineer Commission during the First Twenty-five Years of its Existence.

H. O.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XX., NO. 12. The Relation of the Defensive to the Offensive Naval Power of a State. Rapid-firing Guns of Large Caliber (concluded). The 15-cm. Gun of Schneider & Co.

A complete description of the gun, with an account of its trial, and plate.

The Dimensions of a Modern Man-of-War.

A review of the lecture on this subject delivered by Captain Wilmot, R. N., before the Royal United Service Institution.

German Naval Budget for 1893. Description of the ship San Gabriel in which Vasco de Gama discovered the passage to the East Indies. Armored Ships and Explosives (trans.). Supplementary Remarks on the Destruction of the Blanco Encalada. The English Battleships Revenge and Royal Oak. The United States Cruiser Olympia. The Argentine Armored Ram Libertad. New Designation of Different Degrees of Engine Power Adopted by the British Admiralty (trans.). The Installation of Torpedoes onboard English War Ships (trans.). H. O.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

JULY, 1892. On Shipbuilding in Portsmouth Dockyard; by Mr. White, Director of Naval Construction. On the Applications of

Electricity in the Royal Dockyards and Navy. Description of the Lifting and Hauling Appliances in Portsmouth Dockyard.

This number is the record of the July meeting at Portsmouth, and the three papers mentioned are all of interest to naval readers. Mr. White gives a short history of the yard and an account of past and present constructions. The second paper describes English practice in the installation of electric power for naval purposes in yards and ships. The last paper noted explains the methods used in the Portsmouth yard for transmitting and using power. Steam, hydraulic, and pneumatic power are all in operation, and experience has shown pneumatic superior to hydraulic power in this particular place; the economical ratio is about 13 to 11 in working capstans. It seems rather remarkable that electricity has not been used as a means of transmitting power, especially as there is quite a large electric plant installed in the yard.

H. S. K.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

VOLUME XX., No. 1, JANUARY, 1893. Defense of a Coast Fortress. Recent Development of Armor and its Attack by Ordnance.

Captain C. Orde Browne, *late* R. A., continues the subject which had been treated in a series of articles terminating in 1887, and brings it up to date. A mass of data is collated concerning armor trials during the past five years, and some deductions drawn therefrom.

No. 2. Recent Development of Armor, etc. (continued).

Captain Browne continues his subject, and speaks briefly of the use of high explosives, steel armor-piercing common shell, angular impact with A. P. common shell, and woodite, and more at length of Grüson's shielded mountings. This article concludes with a comparison between the perforation formulæ of Fairbairn, Maitland, de Marre, and Krupp, together with some experimental data in test of their accuracy.

H. S. K.

REVUE DU CERCLE MILITAIRE.

OCTOBER 9, 1892. The First Engagements of the Army of the Rhine; from the Notes of an Officer. The New Drill Regulations and Interior Discipline for Italian Infantry.

OCTOBER 16. Drill of the Sanitary Corps attached to the Military Department of Paris. The Divisions of the Reserves at the Manœuvres of 1892. The Ministry of War and the Landwehrs in Austro-Hungary.

OCTOBER 23. The First Engagements of the Army of the Rhine, etc. The Sanitary Corps of the Military Government of Paris.

OCTOBER 30. The Ministry of War and the Landwehrs in Austro-Hungary.

NOVEMBER 13. The Chinese Army of the Green Standard.

NOVEMBER 27. Medical Statistics of the French Army for 1890. Rousseau's Pile and Accumulators (with plates). The Prism-telemeter Souchier.

DECEMBER 11. The Prism-telemeter Souchier (with sketch).

DECEMBER 18. The New Manageable Balloon at Chalais-Meudon.

DECEMBER 25. The Ministry of War and the Landwehrs in Austro-Hungary.

JANUARY 1, 1893. The Military School of Portugal. The New Hebrides Archipelago. The Chinese Army of the Green Standard (continued).

JANUARY 8. Commandant Monteil's Travels in Central Africa.

JANUARY 15. War a Hundred Years Hence. The New Hebrides (ended).

JANUARY 22. The Staff Duties during the Late Military Manœuvres, from the Personal Notes of an English Officer. The Chinese Army of the Green Standard (continued). War a Hundred Years Hence (ended).

JANUARY 29. Field Hospitals. The Combat of Infantry during the Manœuvres of 1892, from the Notes of an English Officer.

FEBRUARY 5. The New Decree concerning Interior Discipline in the Infantry Corps.

FEBRUARY 12. Field Hospitals (with map). The New Decree Concerning Interior Discipline in the Infantry Corps.

FEBRUARY 19. Field Hospitals (with map). The Military Association of Berlin. The New Decree on the Interior Service of the Infantry (ended). J. L.

REVUE MARITIME ET COLONIALE.

DECEMBER, 1892. The Civil War in Chile; Sinking of the Blanco-Encalada by the Torpedo-boats Condell and Lynch.

"This is the first affair in which the Whitehead torpedo manifested its destructive effects in actual warfare, but does not otherwise shed new light on the relative value of torpedo-boats as against armored ships. Circumstances made the task of the Condell and Lynch easy. We may, however, reiterate here what has often been said, and that is, to remain over night at anchor in open roads will be found extremely hazardous; and, if imperative to do so, the commander must protect his vessel with torpedo-nets and send out well organized boat's crews as scouts."

In the Land of the Kanacks (continued). A Study of the Mechanical Theory of Heat. Coal in the Extreme East (Annam, Tonkin, etc.). Historical Studies of the Military Marine of France.

FEBRUARY, 1893. French Interests in Canada. A New System of Compass Cards of Light Weight. In the Land of the Kanacks (continued). The Ancient Troops of the French Navy. The Civil War in Chile (ended). A Study of the Mechanical Theory of Heat (continued). J. L.

RIVISTA MARITTIMA.

JULY AND AUGUST, 1892. First Steps in Nautical Science. Notes on Powders and Explosives (continued).

SEPTEMBER. The Fleet of Discovery (year 1492).

An interesting illustrated article giving many particulars, including the names of the officers and crews of the vessels.

Recent Improvements in Marine Machinery. Notes on Powders and Explosives (continued).

OCTOBER. First Steps in Nautical Science (continued). Notes on Powders and Explosives (continued).

NOVEMBER. First Steps in Nautical Science (continued). Notes on Powders and Explosives (continued). On the Fiske Range Finder.

DECEMBER. Recent Improvements in Marine Machinery (continued from September number). First Steps in Nautical Science (concluded). On the Fiske Range Finder (concluded). On the Use of Electricity for operating Steering Engines from Distant Points and for Indicating the Position of the Helm. Notes on Powders and Explosives (continued).

JANUARY, 1893. The English Naval Manœuvres of 1892. Notes on Powders and Explosives (continued).

FEBRUARY. Torpedo-boats. The Hydrographic Office at Washington and the Pilot Chart of the Atlantic. Recent Improvements in Marine Machinery (continued from December number). Notes on Powders and Explosives. W. F. W.

THE STEAMSHIP.

VOLUME IV., NO. 42, DECEMBER, 1892. The Development of the Machinery of Atlantic Liners. German Feed Heaters and Surface Condensers. The Work and Treatment of Firemen. The Efficiency of Screw Propellers.

JANUARY, 1893. Ice-making and Refrigerating on board Ship. Marine Boiler Furnaces. The Steam Navy of England. A New Lifeboat. European Navies; list of vessels.

FEBRUARY. Marine Boiler Furnaces. Simplex and Huge Torpedoes. Whale-back Steamer for World's Fair Traffic. Arrangement of Cylinders and Cranks in Triple-expansion Engines. Repairing a Propeller Shaft at Sea. H. S. K.

UNITED SERVICE GAZETTE.

JANUARY 14, 1893. The Court-martial on Vice-Admiral Fairfax.

JANUARY 21. Guns on board Ship.

A paper criticising the disposition of the guns on English battleships and comparing them unfavorably with the French.

JANUARY 28. Electric Balloon Signaling. The Next Naval Programme.

FEBRUARY 4. Launch of the Cambrian. Our Naval Supremacy.

FEBRUARY 18. War and the Mercantile Marine.

C. M. K.

LE YACHT.

OCTOBER 8, 1892. Composition of the French Fleet in European Waters. Trial of a Rapid-fire Canet Gun of 10 cm.

OCTOBER 15. The French Navy Budget. The Armored Cruiser Latouche Tréville. Launch of the Armored Coastguard Valmy.

OCTOBER 22. The Torpedo-boat Question in England.

The writer, M. Weyl, comments at some length on the diversity of opinion in England regarding the field for torpedo-boat operations. One party, with Mr. W. Laird Clowes, correspondent of the *Times* at the late manœuvres, as its champion, considers the torpedo-boat an offensive and defensive weapon, capable of making long-distance raids. The other would confine torpedo-boat operations to the vicinity of the shore. The Admiralty meanwhile goes ahead with its construction of 14 sea-going boats of 200 tons and 27 knots, as provided for in the programme of 1892-93.

OCTOBER 29. The New Organization of the Naval Reserve.

NOVEMBER 5. Mobilization of Auxiliary Cruisers.

NOVEMBER 26. Use of Crude Oil as Fuel in the Navy. The New Yacht Measurement. Melinite Shells.

DECEMBER 3. The Navy in Dahomey. The Firing on board the Normandie. Guns, Torpedoes and Armor (E. Weyl). The Accident to the Howe.

DECEMBER 10. Note on the Electric Propulsion of Boats.

DECEMBER 17. General Assembly of the Union of French Yachts.

DECEMBER 24. The Institution of Naval Architects and the "Association Technique Maritime."

DECEMBER 31. The Italian Navy.

This is in substance the history of the rise of the maritime power of Italy.

The Chilian Battleship Capitan Prat.

JANUARY 7, 1893. The Navies of the World in 1892. The New Ring-tubes for Boilers in Use on board English War-ships.

JANUARY 14. The Navies of the World (ended). "Association Technique Maritime." Determination of the Mechanical Elements of Helicoidal Propellers.

JANUARY 21. The Navy Ministerial Changes; Officers' Promotions. The Third-class French Cruiser Troude.

JANUARY 28. "The Captain of the Mary Rose," by W. Laird Clowes.

A naval fiction of the same category as the battles of Dorking and Port Said.

FEBRUARY 4. The Navy Appropriations in the French Chambers (E. Weyl).

FEBRUARY 11. Diffusion of Light through Water, and its Appliances in the Navy. The Atlantic Flying Division, etc.

FEBRUARY 18. The Navy of the United States (E. Weyl).

FEBRUARY 25. The Establishment of Sailors' Homes in France. Heavy Oils as Fuel on board of Men-of-war.

Very interesting experiments have been going on for some time past in Russia, France, Italy, as well as in the United States, in regard to the use of the residuum of heavy oils for firing purposes, and the results were such that no doubt is left in the minds of experts as to their ultimate adoption on board of a certain class of war-ships. The following are the principal advantages of this method of generating steam: (1) decrease in the number of stokers and coal-heavers; (2) increase of radius of action; (3) absolute absence of smoke with well-regulated fires.

J. L.

EXCHANGES, BOOKS AND PERIODICALS RECEIVED.

American Chemical Journal.

Annual Report of the Commander, First Naval Battalion of the State of New York; 1892.

Annual Report of the Inspector-General to the Secretary of War; 1892.

Bulletin of the American Geographical Society.

Bulletin of the American Iron and Steel Association.

Colliery Engineer.

Engineer, New York.

Engineer-Mechanics.

Geographical Society of California.

Handbook of Military Signaling.

Journal of the Association of Engineering Societies.

Journal of the United States Cavalry Association.

Lend-a-Hand.

Los Orijenes de Nuestra Marina Militar por Luis Uribe Orrego, Contra-Almirante de la Armada. Parte Segunda, 1819–1823; Las Campanas de Lord Cochrane.

Mémoires et Compte Rendu des Travaux de la Société Ingénieurs Civils.

Moniteur de la Flotte.

Norsk Tidsskrift for Sovaesen.

Occasional Papers of the California Academy of Arts and Sciences.

Proceedings of the American Philosophical Society.

Railroad Gazette.

Report of the Superintendent of the U. S. Naval Observatory for the Year ending June 30, 1892.

Revista Maritima Brazileira.

Revista Tecnológico Industrial.

Rivista di Artiglieria e Génio.

Stevens Indicator.

Teknisk Tidskrift.

Tenth Annual Report of the Executive Committee of the Indian Rights Association for the Year ending December 15, 1892.

Tidskrift i Sjövasendet.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.
TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.
UNITED SERVICE GAZETTE.
UNITED SERVICE.

REVIEWERS AND TRANSLATORS.

Lieut.-Comdr. J. P. MERRELL,
Lieutenant HUGO OSTERHAUS,
Lieutenant W. F. FULLAM,
P. A. Engineer W. F. WORTHINGTON,
Ensign C. M. KNEPPER,
Professor JULES LEROUX,
Lieutenant H. S. KNAPP.

ANNUAL REPORT OF SECRETARY AND TREASURER OF THE U. S. NAVAL INSTITUTE.

TO THE OFFICERS AND MEMBERS OF THE INSTITUTE:

Gentlemen:—I have the honor to submit the following report for the year ending December 31, 1892.

ITEMIZED CASH STATEMENT.

RECEIPTS DURING YEAR 1892.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Advertisements	$112 50	$308 75	$20 00	$40 00	$481 25
Dues	1099 56	417 00	183 00	247 50	1947 06
Sales	100 30	484 89	79 07	165 80	890 06
Subscriptions	223 15	182 25	145 40	251 70	802 50
Life membership fees	..	30 00	..	..	30 00
Binding	31 25	5 71	2 50	8 25	47 71
Interest on investments	64 71	9 00	45 50	38 00	157 21
Insurance recovered	1000 00	..	..	..	1000 00
Credits on account	20	1 20	10 67	1 71	13 78
Prepayment of expressage and postage	..	..	..	68	68
Profit and loss	..	..	..	3 00	3 00
Totals	$2691 67	$1438 80	$486 14	$756 64	$5373 25

EXPENDITURES DURING YEAR 1892.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Printing publications	$8 90	$652 78	$495 51	$481 00	$1638 19
Advance payment for printing No. 64	..	..	..	200 00	200 00
Binding	24 80	105 00	..	29 93	159 73
Expressage	4 39	6 95	2 65	3 30	17 29
Freight and hauling	65	2 22	2 93	2 35	8 15
Postage	41 25	27 50	28 45	51 36	148 56
Stationery	22 50	8 00	36 25	..	66 75
Telegrams	1 68	70	50	..	2 88
Secretary	90 00	81 00	..	189 00	360 00
Clerk	120 00	130 00	150 00	150 00	550 00
Office expenses	67	..	1 60	8 82	11 09

EXPENDITURES—*continued.*

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Expenses, recovery of insurance	$4 70	..	..	..	$4 70
Purchase D. C. Bonds	114 30	..	..	..	114 30
Purchase of back numbers	8 00	3 90	..	..	11 90
Purchase of Postal Guide	2 50	..	..	..	2 50
Subscription Army and Navy Register	3 00	..	..	..	3 00
Repairs to typewriter	2 50	..	..	..	2 50
Gold medal and engraving	16 25	..	..	..	16 25
Discount on foreign remittances	07	..	..	06	13
Expenses Newport Branch	21	..	..	..	21
Expenses Washington Branch.	..	20	14	14	48
Annual Prize	..	100 00	..	..	100 00
Expenses business trips	..	2 75	2 50	1 40	6 65
Half profits to Comdr. Glass on No. 34	..	10 51	..	..	10 51
Subscription Navy and Marine Corps Directory	..	..	5 00	..	5 00
Transfers from credits	..	..	..	2 80	2 80
Totals.	$466 37	$1131 51	$725 53	$1120 16	$3443 57

SUMMARY.

Balance of cash unexpended for the year 1891	$2050 02
Total receipts for 1892	5373 25
Total available cash, 1892	$7423 27
Total expenditures for 1892	3443 57
Cash unexpended, January 1, 1893	$3979 70
Cash held to credit of Reserve Fund	42 89
True balance on hand, January 1, 1893	$3936 81
Bills receivable for dues 1892	567 60
" " " back dues	539 50
" " " binding	12 50
" " " subscriptions	8 00
" " " sales	14 52
Value of back numbers (estimated)	1875 00
" " Institute property (estimated	100 00
Total assets	$7053 93

The liabilities of the Institute consisted on January 1st of the balance due on the bill for printing whole No. 64, which had not been delivered on that date, and a small bill for second class postage, neither of which bills had been rendered.

Reserve Fund.

List of bonds deposited for safe-keeping in the Farmers' National Bank of Annapolis, Md.:

United States 4 per cent consols, registered	$900 00
District of Columbia 3.65 per cent registered bonds	2000 00
" " " 3.65 per cent coupon "	450 00
	$3350 00
Cash in bank uninvested	42 89
Total Reserve Fund	$3392 89
Number of new life members, one the prize essayist for 1892	2

Of the above amount invested, there were added during the year two District of Columbia bonds, 3.65 per cent, face value $100.00, which were purchased for $114.30.

Membership.

The membership of the Institute to date, January 1, 1893, is as follows: Honorary members, 6; life members, 105; regular members, 553; associate members, 188; total number of members, 852.

During the year 1892 the Institute lost 15 members by resignation and 7 by death; 35 new members' names were added to the rolls — 10 regular, 23 associate, and 2 life members; 1 regular member became a life member.

Members Deceased since January 8, 1892.

Life Members.

Bolles, T. Dix, Lieutenant, United States Navy, August 23, 1892.

Regular Members.

Clark, A. B., Chief Engineer, United States Navy, April 19, 1892.
Dalrymple, E. W., June 21, 1892.
Roosevelt, N. L., December 14, 1892.

Associate Members.

Cowles, Eugene H., ——, 1892.
Drayton, Percival L., June 24, 1892.
Wright, Geo. F., August 20, 1892.

Publications on Hand.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

	Plain copies.	Bound copies.
Whole No. 1	104	..
2	240	..
3	61	..
4	146	..
5	121	..
6	1	..
7	7	..
8	35	..
9	39	..
10	5	..
11	215	..
12	52	..
13	3	..
14	4	..
15	1	..
16	221	..
17	..	..
18	103	..
19	103	..
20	118	1
21	227	1
22	268	1
23	176	1
24	186	1
25	1139	45
26	204	80
27	300	27
28	2	17
29	211	9
30	245	6
31	37	57
32	3	173
Whole No. 33	9	162
34	35	28
35	141	6
36	263	29
37	192	24
38	231	2
39	220	2
40	25	113
41	251	19
42	105	19
43	156	3
44	55	10
45	38	19
46	41	19
47	21	19
48	40	18
49	18	17
50	56	17
51	29	18
52	51	16
53	146	35
54	5	8
55	54	17
56	535	55
57	14	22
58	..	22
59	..	13
60	93	2
61	180	20
62	192	20
63	371	6

1 Vol. X., Part 1, bound in half morocco.
1 No. 34, bound in half morocco.
3 " " " " " calf.
1 " " " " full sheep.
4 " 63 " " flexible leather.
15 " " " " " cloth.

Very respectfully,

H. S. KNAPP, *Lieut., U. S. Navy,*
Secretary and Treasurer.

ANNAPOLIS, MD., January 1, 1893.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1894.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the Prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1893. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

H. S. KNAPP, *Lieut., U. S. N.*,
Secretary and Treasurer.

ANNAPOLIS, MD., *April* 1, 1893.